



JBS Townsville

Environmental Evaluation of Wastewater Irrigation

Response to A Request

DES CA4544; 101/0008424

Part 1 - Irrigation of Wastewater (ver.1)



Prepared for

JBS Australia

By

Bio-Track Pty Ltd

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1 INTRODUCTION

Bio-Track Pty Ltd has been commissioned by JBS Australia Pty Ltd to prepare a response to a request from the Department of Environment and Science (Notice to conduct or commission an environmental evaluation, CA4544; 101/0008424, dated 19 April 2018).

It is assumed the reader is familiar with the Department of Environment and Science notice details.

2 DESCRIPTION OF THE WASTEWATER IRRIGATION PRACTICES

The Townsville abattoir operates for approximately 10 months of the year. Wastewater flows from the facility to anaerobic, facultative and aerobic ponds. The pond layout is shown in Figure 1. The dimensions of ponds and irrigation areas are provided in Appendix 4.

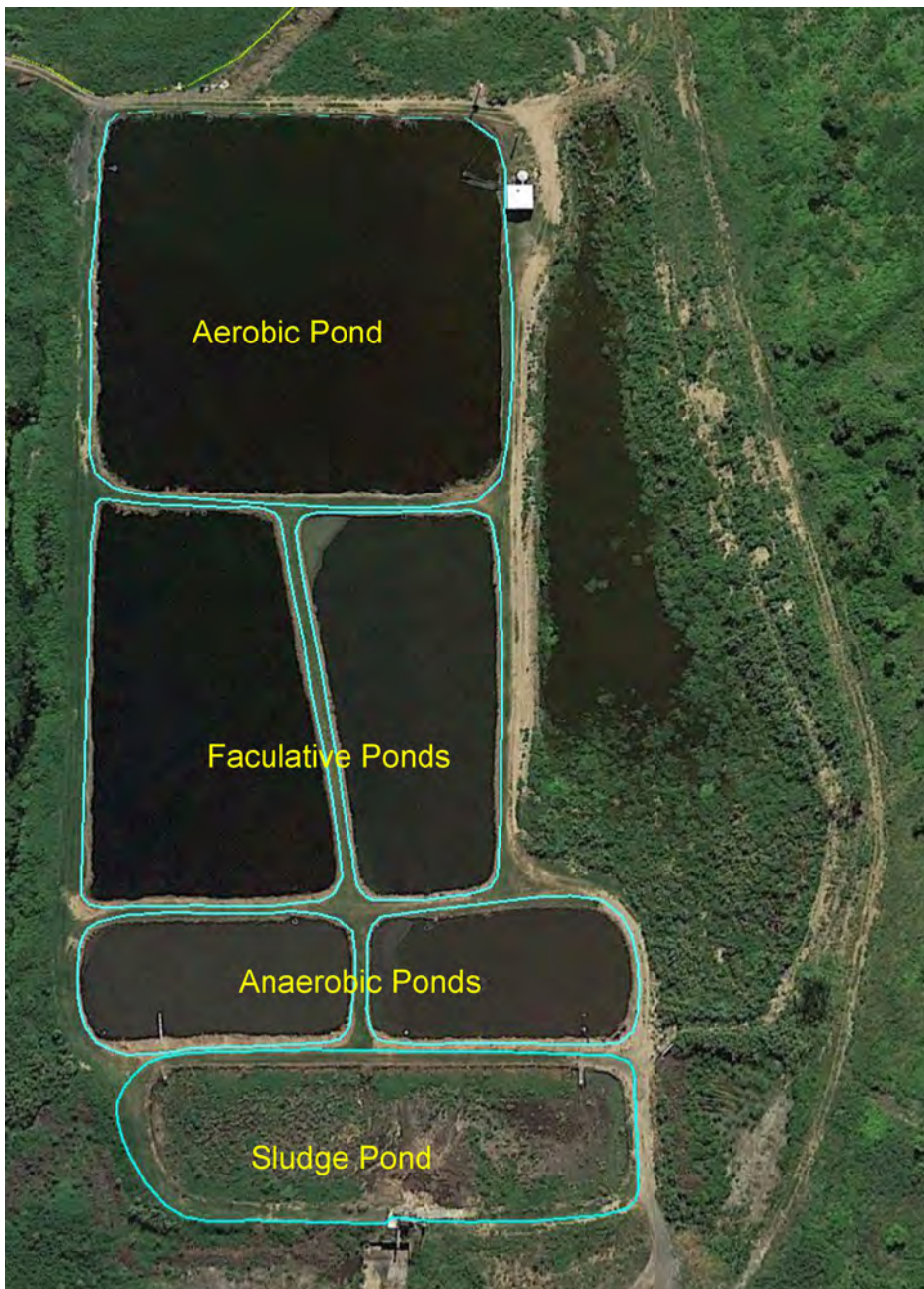


Figure 1: Treatment Ponds

The effluent from the final pond is monitored. The long term average values of the effluent have been used in this study. These are provided in Table 1.

Analyte	Value	Units
Total Nitrogen	130	mg/L
Total Phosphorus	30	mg/L
Dissolved Salt	813	mg/L
Electrical Conductivity	1.95	dS/m
Biological Oxygen Demand (5 day)	76	mg/L

Table 1: Effluent Composition

The influent flow varies according year to year. A typical year has operation starting on year day 76 and finishing on year day 350. This schedule has 195 working days per year, with an influent wastewater flow of 1.33 ML/day. The annual wastewater influent flow is 260 ML/year.

The facility has an area of 266 hectares with 95 hectares being available for irrigation. The irrigation methods are spray and flood irrigation. Flood irrigation is rarely undertaken. Most of the irrigation water is applied to the spray

irrigation areas. The spray irrigation area is 65 ha and the flood irrigation area is 29 ha. The irrigation area runoff is to a tailwater recovery dam. This water is harvested for irrigation. The crop is Rhodes' grass. This is harvested for off-site re-use as fodder grass.

Irrigation is applied using traveling irrigators. The wetted width is 50 metres and the run length is 120 m. A network of hydrants is used. Several irrigators are used across the site, depending on the supply and demand. Water is applied across the spray irrigation areas in rotation. Application is made when the soil moisture has fallen and when irrigation water is available. There is typically insufficient water to meet the full plant water requirements. When ponding or runoff appears likely, irrigation is not applied and water is retained in the storage lagoons.

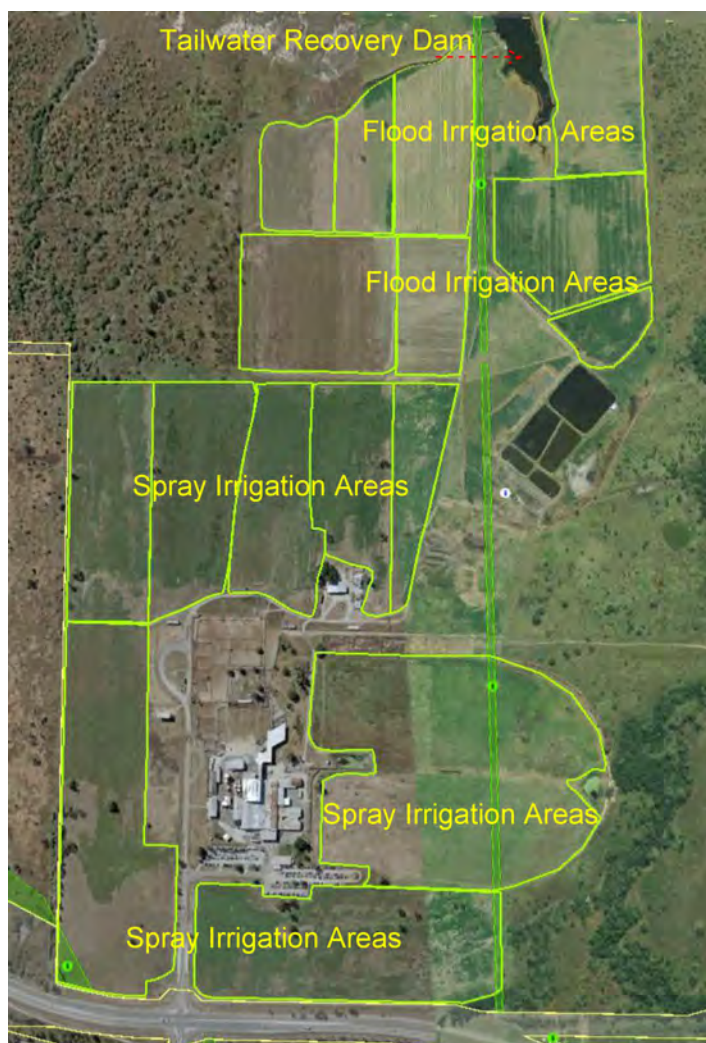


Figure 2: Irrigation Areas

3 MODELING OF IRRIGATION

The MEDLI model has been used to describe the performance of the irrigation system. Input and output parameters used in the model are provided in Appendix 1. The irrigation areas are located on a coastal plain with low slope with silty clay, overlying, slowly permeable clay subsoil. Soil profile description and chemical analysis is presented in Appendix 2.

A daily supply of wastewater of 1.33 ML/d has been applied, corresponding to the period of operation (year day 76-350).

Flood irrigation is rarely used and has not been undertaken for a number of years. The modeling is based on spray irrigation. There is no tail water associated with properly managed spray irrigation and the modeling has assumed no tail water recovery.

Two important considerations have been assessed. These are hydraulic control and nutrient control.

3.1 Hydraulic Control

This approach assesses the crop water demand to ensure a zero discharge outcome can be achieved.

Figure 3 examines irrigation of irrigation areas between 30 and 100 hectares of irrigated Rhodes grass. The irrigation technique is simply irrigating every 14 days, at rates not exceeding 50 mm/d of water, irrespective of the rainfall. This schedule forces all irrigation to be applied so there is no release of water. In practice, irrigation is applied when runoff and ponding does not occur.

Irrigation of land areas smaller than 50 hectares is associated with elevated nutrient loading and predictions of elevated nutrient concentration in deep drainage. When 50 hectares, or more, land is irrigated then the nutrient control is acceptable. When 50 hectares are irrigated, the irrigation rate is 480 mm/year and this is 58% of the full crop demand for water.

A total of 95 hectares is available, with 65 hectares being available for spray irrigation. Water collected in a 15 ML tail water dam is also irrigated across the irrigation area. Release from the tail water dam will occur after more than approximately 17 mm of rainfall runoff occurs. No release of water from the treatment lagoons has been recorded. The large area available for irrigation and the relatively dry weather conditions during the abattoir operational period permit 100% re-use rates to be easily achieved.

One release from the tail water recovery dam was recorded in March 27, 2018. This was during a non-operational period when wastewater was not being generated. The test results are provided in Appendix 2. The nutrient concentration is within the range expected for runoff from a conventional fertilised pasture grass farm.

3.2 Nutrient Control

The Rhodes grass cropping system has the potential to utilise high rates of nutrient and water, if this is available. One hypothetical, "high rate" example has been modeled. This only irrigates 10 hectares of land. The crop is irrigated based on soil water deficit. Irrigation water is only applied to replace that used by transpiration. The irrigation rate 815 mm/year. The nutrient uptake rate is 813 kg N/ha/y and 161 kg P/ha/y. This demonstrates the crop has the potential to utilise more water and nutrient than is currently being applied.

Nitrogen Control

A summary of the mass loads for irrigated nitrogen is provided in Table 2.

Inputs

The input from irrigated wastewater is based upon the volume of water that is pumped from the treatment lagoons and the nutrient concentration. The volume allows for loss in evaporation as predicted by the MEDLI model.

The calculated nitrogen supply is 28,194 kg/year.

Crop Removal

The mass of harvested hay and nutrient composition of the hay is recorded. The hay harvest records are provided in Appendix 3.

The crop removal is based upon the measured mass of hay and the measured nitrogen concentration in this hay. The average hay nitrogen concentration is 1.88% and the 2017 harvested mass is recorded at 1076 tons. The harvested nitrogen mass is calculated to be 21,240 kg in 2017. This is 72% of the irrigated nitrogen mass.

(The MEDLI program predicts 25 ton/ha/y biomass harvested for a 60 hectare irrigation. This is equivalent to 1,500 tons. The measured rate is 1076 tons.)

Leaching

The groundwater nitrogen measured in 2016 from 3 monitoring bores is less than 0.1 mg/L

In 2017 the groundwater nitrate N levels were 0.03, 0.03 and 0.25 mg/L.

In 2018 shallow groundwater from five bores was measured. The total nitrogen levels ranged from 0.2 to 1.5 mg/L (nitrate N 0.2-0.7 mg/L). The groundwater is saline and this is characteristic of low rates of deep drainage. Whilst fast leaching rates could explain low nitrogen levels, this does not apply for the study area.

The MEDLI model predicts the deep drainage rate is 39 mm/y for a 60 hectare irrigation rate. If 0.5 mg N/L is used to represent the site average groundwater concentration then the drainage loss is 12 kg/y.

Hay Nitrogen Loss

The measured hay nitrogen concentration is quite variable. This will be affected by the nitrogen loading rate of the hay that is sampled. Hay is harvested from across the site and this will be from land that is not irrigated, lightly irrigated, well irrigated, etc. When cut, dry matter and nitrogen is lost from hay. Dry matter losses of 10-30% can be expected (M B Enoh, C Kijora*, K J Peters*, V N Tanya, D Fonkem and J Mbanya, 2005). Crude protein losses of 17% are reported by the same authors during the period between the pasture content and the hay at baling. Therefore monitoring of harvested mass and harvested nitrogen levels is prone to underestimate the nitrogen present in grass, when cut. For example if the measured mass is 90% of the mass when cut and the nitrogen level is 85% then the reported harvest is 76% of the cut grass nitrogen level.

For the purpose of this study a 15% nitrogen loss is applied between harvest and measurement of the hay. The baling loss is 11% of the supply.

Runoff Loss

Runoff can carry nitrogen in particulate and dissolved forms. The irrigation areas flow to a tail water recovery dam and this water is subsequently re-irrigated. Denitrification will occur in the dam, possibly at very high rates. The irrigation areas are typically short of water and the tailwater dam rarely overflows, except after extended periods of heavy rain. Whilst some loss will occur (e.g., March 2018), the loss is assumed to be infrequent and at a low concentration (e.g., ≤ 5 mg N/L). It is very difficult to accurately measure the volume associated with such events. Small runoff events are predicted to have a higher nutrient concentration due to first flush effects. A preliminary estimate using the relationship:

$$\text{Runoff N mg/L} = 5 \times 17 / \text{Runoff mm}$$

has been applied to runoff events greater than 17mm. For example a 34 mm runoff event is calculated to have a concentration of 2.5 mg/L. This provides a dilution effect for runoff events greater than 17 mm. Runoff events less than 17 mm are assumed to be captured and re-irrigated.

The annual average loss of nitrogen is then calculated to be 193 kg for a 65 hectare area or 3 kg/ha/y. Whilst this calculation does provide an export rate within the range commonly applied to pasture, it is based on only one water test measurement.

Soil Denitrification

Soil nitrogen is subject to a series of transformations. The classic sequence is:

Organic -> Ammonia -> ->plant uptake

Organic -> Ammonia ->Nitrate ->plant uptake
->Nox->atmospheric loss
->leaching loss

Both the ammonia and nitrate forms are available for plant uptake and the nitrate form is also subject to denitrification. Denitrification is fastest when the soil is depleted of oxygen (e.g., very moist), has an organic carbon supply (e.g., within the root zone) and is warm (e.g., a tropical climate). All three conditions are present within the plant root zone of any soil irrigated in Townsville. Much research has been undertaken on the subject as denitrification reduces the performance of expensive fertiliser and leads to run-down of nutrient levels in all soil systems, unless replaced at an equal rate. A universal feature of tropical soils is an extremely low organic matter and low organic nitrogen level. In almost all moist soils, approximately 98-99% of the soil nitrogen is present as organic nitrogen, except where the soil has been recently fertilised.

The MEDLI program assigns a 10% nitrate nitrogen loss rate per day, within the organic soil layer (layer with biodegradable organic carbon), but does not specify the moisture and temperature conditions when this rate applies. For the purposes of this study, a threshold value, equivalent to 80% of field capacity has been selected. This is the lowest soil moisture at which denitrification is calculated. At moisture contents of 80% and higher, a denitrification loss rate of 10% per day is assumed. In practice, denitrification will occur at lower rates, in small areas of soil which have little oxygen, at lower levels of soil moisture. The MEDLI program predicts quite low levels of denitrification. It appears crop uptake is modeled as the preferential pathway and residual nitrate nitrogen is then potentially subject to leaching or denitrification. This will bias the predicted outcome towards crop uptake.

When soil is irrigated, the moisture level at the surface rises and is normally above the threshold for denitrification. The soil will initially wet a depth of soil to field capacity. Then the soil dries down through evapotranspiration. The soil, wetter than the denitrification threshold is subject to denitrification for a period of time. The period of time is a function of the irrigated volume. The loss of nitrogen is also a function of the initial nitrate concentration.

Table 3 describes soil denitrification as a function of applied irrigation. The more water is applied, the greater is the affected soil volume and the longer the wet soil will denitrify until it dries out.

Table 2: Nitrogen Mass Balance

COMPONENT	Rate	Units
Wastewater Inflow To Pond	255.0	ML/y
Pond Evaporation	38.1	ML/y
Wastewater Outflow From Pond	216.9	ML/y
Irrigation Wastewater N Supply	130	mg/L
	28194	kg/y
Irrigation Area	60	ha
Hydraulic Loading	3.61	ML/ha/y
	361	mm/y
Runoff Loss	2.97	kg/ha/y
Nitrogen Loading Rate To Land	470	kg/ha/y
Hay Harvested 2017	1076	ton
Hay N Content	1.88%	
N Harvested	20	ton
	20229	kg
	72%	of supply
N Lost Post Harvest	15%	
	3034	kg/y
	11%	of supply
Biomass N	23263	kg/y
# Irrigations Applied Annually	10	times/y
Irrigation Application/Event	35	mm
De-Nitrification	17%	applied N
	4733	kg/y
Deep Drainage	39	mm/y #
	0.5	mg N/L *
	11.7	kg/y *
INPUTS & OUTPUT		
N Input	28194	kg/y
N Harvest	20229	kg/y
Harvest N Loss	3034	kg/y
Leaching	12	kg/y
Runoff	178	kg/y
Soil Denitrification	4733	kg/y
Net Balance	9	missing
	0.0%	
#	MEDLI prediction	
*	Measured 2018 in shallow groundwater	

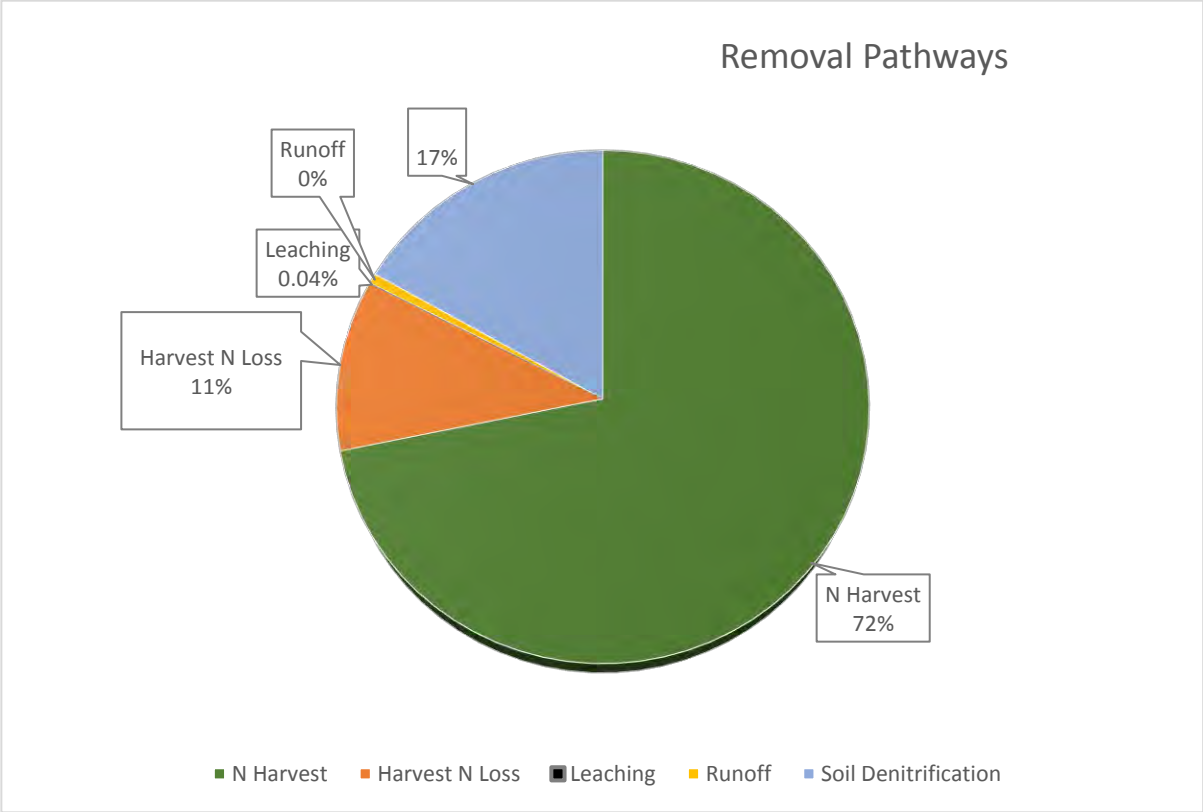
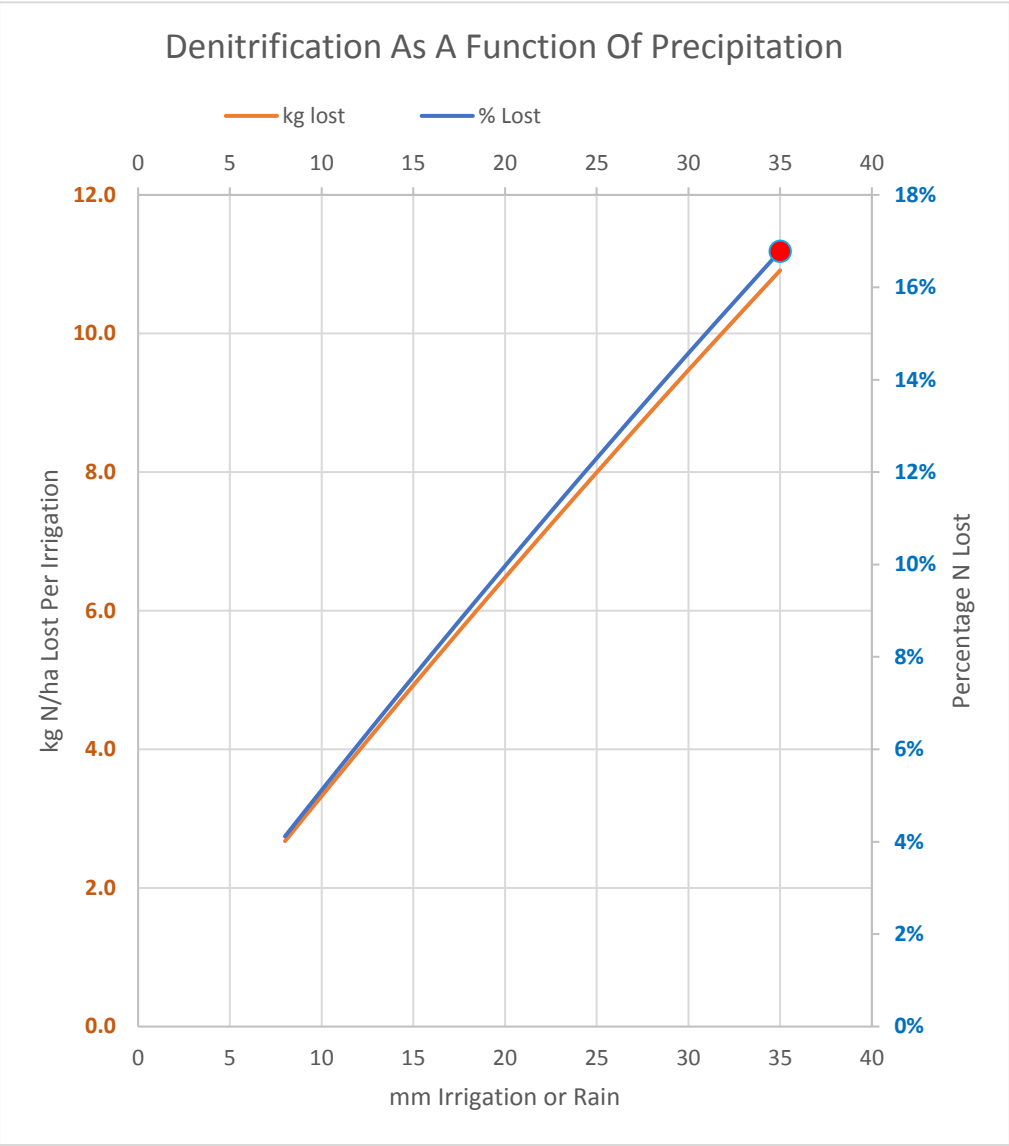


TABLE 3: Soil Denitrification Losses		
Component	Rate	Units
Irrigation N Conc	130	mg N/L
Irrigation Applied	35	mm
Irrigated Volume	35	L/m2
	500	kL/ha
	0.5	ML/ha
Irrigated Nitrogen	4550	mg/m2
	65	kg/ha
M.C. @ Field Capacity	0.52	vol. ratio
P.A.W.	0.13	vol. ratio
M.C. @ Wilting Point	0.39	vol. ratio
Soil Moisture Start (dry)	0.40	vol. ratio
Soil Moisture End (wetted)	0.52	vol. ratio
Added Water	0.12	vol. ratio
	123.5	L/m3
Wetting Front	0.283	m
Bulk Density	1.55	g/cc
Air Filled Porosity oven dry	0.43	vol. ratio
Air Filled Porosity Start	0.82	vol. ratio
Air Filled Porosity End	0.95	vol. ratio
Dry Mass Soil Wetted	439	kg
Conc N Added To Soil	10.4	mg N/kg soil
Evapotranspiration	4	mm/d
Time To Dry	9	days
Threshold M.C. For Denitrification	0.8	frac of F.C.
Period Of Denitrification	1.75	days
Denitrification Rate	0.1	per day
	-0.105	k
Residual NO3	8.6	mg/kg
N Noss	1.7	mg/kg
% Denitrified	17%	of applied N
	10.9	kg/ha



There are many variables that will apply and a more complex model is attractive. Unfortunately, this lies beyond the scope of this study. For example, a traveling irrigator will provide different rates of application, depending on the distance from the spray head. The marginal areas get close to zero water. There will be other areas with higher rates of irrigation. A more complex model therefore needs to consider a detailed analysis of the wetted soil conditions, before denitrification is calculated. However, the simple model shown in Table 3 remains useful. For example, if 35 mm of water is applied, the period of denitification is predicted to be 1.75 days and a nitrogen loss of 17% occurs.

A denitrification loss rate of close to 17% is sufficient to provide a nitrogen balance for the irrigation area.

It is concluded little nitrogen is being lost to deep drainage. More significant pathways are harvest loss and soil denitrification. Errors in measurement of harvest biomass and harvested plant composition may also be significant.

Phosphorus Control

Supply:

The design wastewater flow is 255 ML/year.

The design phosphorus concentration is 30 mg/L.

The design phosphorus supply rate is 7650 kg/y

The design irrigation area is 60 hectares.

The design irrigation loading rate is 127 kg P/ha/y.

The measured (average) hay phosphorus content is 0.355% (Tropwater 2017 analysis)

The measured hay harvest is 1076 tons/year.(63 kg/ha/y)

The calculated harvest of hay is 3820 kg/y

The phosphorus surplus is 3830 kg/y (63 kg/ha/y)

MEDLI modelling of a 50 hectare irrigation area irrigated using a soil water deficit replacement program predicts a crop removal of 102 kg/ha/y and a deep drainage phosphorus concentration of 0.08 mg/L.

Phosphorus is expected to be conserved through hay production and there is no volatilisation of phosphorus from the soil. Surplus phosphorus is held in the soil as:

- * soluble phosphorus
- * organic phosphorus
- * exchangeable phosphorus
- * sorbed, non-exchangeable phosphorus
- * insoluble phosphorus as calcium, magnesium, aluminium and iron phosphate

Soluble phosphorus will represent less than 1% and probably less than 0.1% of the soil total phosphorus. This is the pool that is at risk of leaching. Annual soil monitoring for water soluble phosphorus demonstrates this is present at a low level. Exchangeable phosphorus is elevated at the surface (30-50 mg/L Colwell P or 0.05 m H₂SO₄ soluble P) and declines with depth. This is typical of any fertilised pasture. Sorbed-nonexchangeable and insoluble phosphorus comprise the majority of the phosphorus pool. Soil phosphate sorption is relatively rapid and measured using a 17 hour equilibrium period. Soil phosphate precipitation as insoluble phosphate is slow and approximately 100 days of groundwater residence would be required for 98% precipitation in solution. This assumes the soil does not dry out. The soil solute concentration rises as the soil dries and this will force precipitation at faster rates. Some of this will be sparingly soluble and will dissolve during another leaching event. The cycle repeats until essentially all of the soluble phosphorus is removed. The measured groundwater phosphorus levels do not reveal an elevated phosphorus concentration.

Soils most susceptible to release of phosphorus are sandy, have a high rainfall, low salt concentration, shallow groundwater and a short groundwater residence period before entering a stream or the ocean. These conditions do not apply to the study area.

As the surface soil becomes loaded with phosphorus, an increasing proportion then migrates deeper into the soil profile. A number of deeper soil samples have been tested for plant available (and partly mobile) phosphorus. The surface (200 mm deep) soil was 52 mg P/kg. At 500 mm the concentration is 4 mg P/kg and other deeper samples had a similar concentration. This data indicates little phosphorus is moving through the deeper soil. This is consistent with groundwater measurements.

Additional soil samples are being collected for a more detailed profile analysis. These samples will be taken from irrigated areas and tested for mobile and total phosphorus.

Calcium can be applied to the soil as gypsum (calcium sulfate). This is typically used to supply calcium for sodicity control and plant nutrition. The soluble calcium will also combine with soluble phosphorus to form insoluble calcium phosphate. Routine application of gypsum is recommended for these reasons. A treatment rate of 5 tons/hectare, applied every two years is recommended.

5 CONCLUSIONS

Hydraulic Control

- * sufficient land area is available to permit 100% re-use of treated wastewater
- * sufficient storage is available to permit 100% re-use of wastewater

The MEDLI modelling demonstrates sufficient land is available and this is obvious given the large land areas available (up to 90 hectares). The model overestimates crop yield and the associated uptake of nutrient. This is at least partly due to the inability to model separate paddocks in a sequence (which is the actual condition for all large irrigation areas.) For this site, water availability is a limiting factor. This is always going to be the case for systems providing 100% re-use. A system capable of providing 100% re-use will be short of water for most of the time (dry years) in order to have the capacity to provide 100% transpiration capacity during wet times.

Nutrient Control

Nitrogen

- * sufficient land area is available to utilise the full nitrogen load
- * not all the applied nitrogen is being absorbed by the crop
- * not all of the crop nitrogen is being harvested
- * some nitrogen will be volatilised during hay production
- * some nitrogen will be lost through soil denitrification. The potential denitrification rate is sufficiently high to account for the missing nitrogen
- * some nitrogen is lost in runoff
- * groundwater nitrogen concentrations are low and the mass of nitrogen potentially entering the deeper groundwater is low

Phosphorus

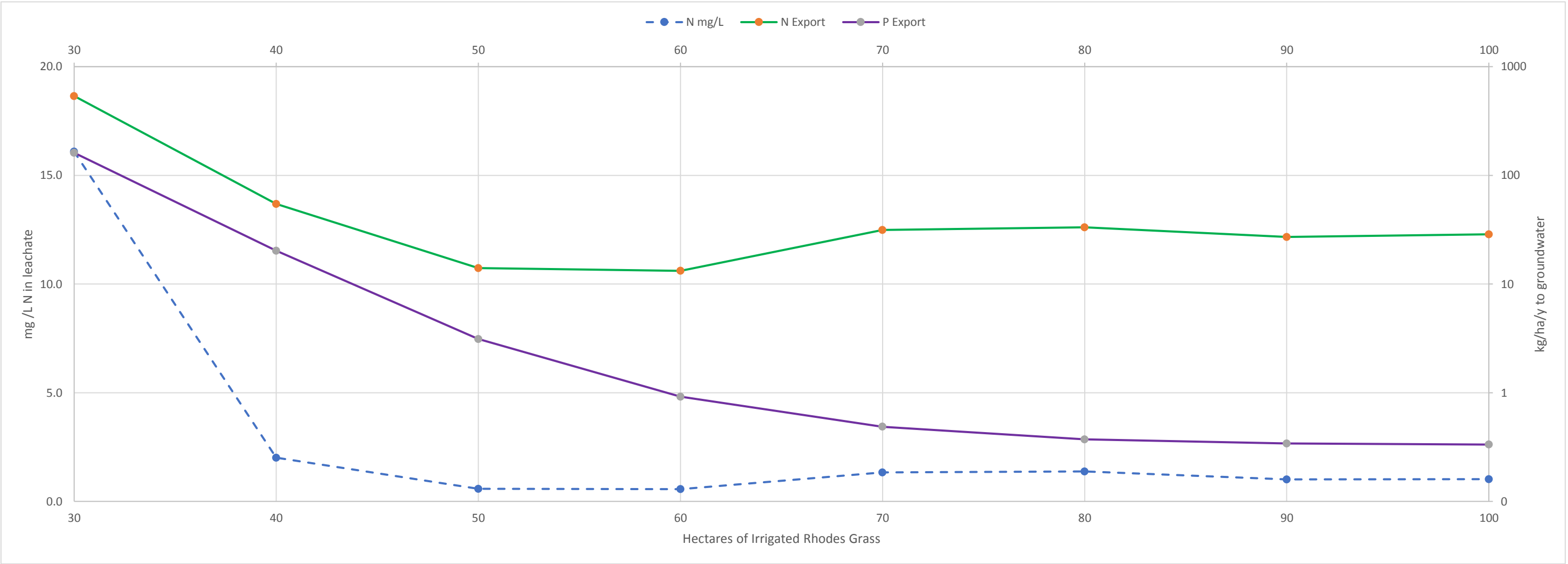
- * crop uptake will remove some but not all the applied phosphorus
- * some phosphorus is lost in runoff
- * soil phosphate sorption will have the capacity to fix a finite mass of phosphorus and the depth of saturated sorption sites will extend deeper down the profile over time. The soil profile has at least 3 metres depth available for phosphate sorption.
- * soil phosphate precipitation will capture the remaining phosphorus. This can be assisted though the application of gypsum.
- * measurements of soil and groundwater demonstrate the labile subsoil phosphorus levels are low and groundwater phosphate levels are acceptable.

Monitoring of hay content and harvest rates will provide an indicative measure of crop removal. A number of limitations affect the accuracy of this for routine agricultural operations.

It is stressed that modelling and other predictions need to be regarded as indicative, rather than a statement of fact. Ultimately the measurements obtained from routine monitoring are essential to indicate the performance of any system.

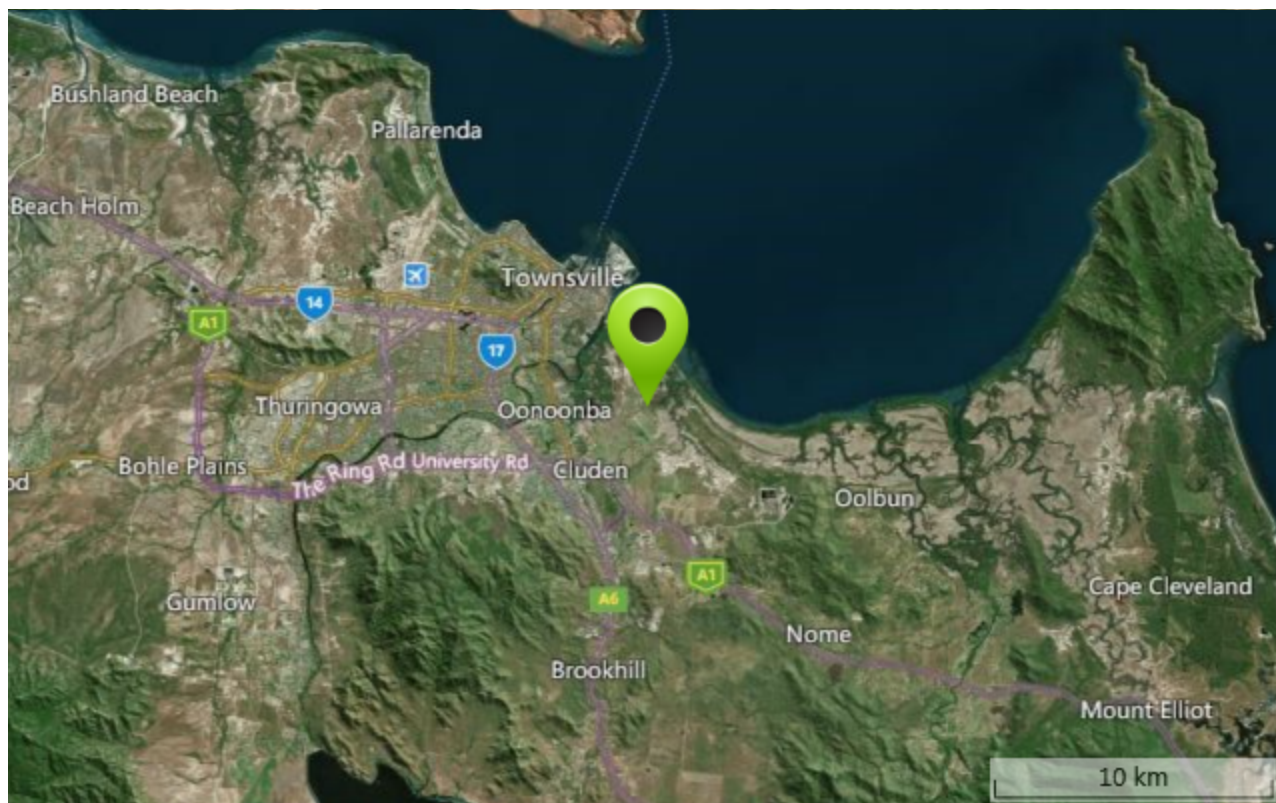
MEDLI SUMMARY																			
Irrigation every 14 days with up to 50 mm, irrespective of rainfall.																			
Irrigation Area (ha)	Pond Volume (m3)	Overflow volume (m3/year)	Effluent reuse (fraction)	Irrigation supplied (mm/year)	Irrigation demand supplied (fraction)	Yield (kg/ha/year)	Phosphate P leached (kg/ha/year)	Nitrate N leached (kg/ha/year)	Av Phosphate P leachate conc (mg/L)	Av Nitrate N leachate conc (mg/L)	Mass N overflowed (kg/year)	Mass P overflowed (kg/year)	Av deep drainage (mm/year)	Mass P to Groundwater (kg/y)	Mass N to Groundwater (kg/y)	N Irrigated kg/ha/y	P Irrigated kg/ha/y	N Control % of Supply	P Irrigated kg/ha/y
30	25500	0	100%	801	96%	35849	5.3742	17.90	4.83	16.09	0	0	111	161	537	1104	255	98.38%	97.89%
40	25500	0	100%	600	72%	31688	0.5067	1.36	0.75	2.01	0	0	68	20	55	828	191	99.84%	99.73%
50	25500	0	100%	480	58%	28043	0.0624	0.28	0.13	0.58	0	0	49	3.1	14	662	153	99.96%	99.96%
60	25500	0	100%	400	48%	25456	0.0153	0.22	0.04	0.56	0	0	39	0.9	13	552	127	99.96%	99.99%
70	25500	0	100%	343	41%	22812	0.0069	0.45	0.02	1.33	0	0	34	0.5	31	473	109	99.91%	99.99%
80	25500	0	100%	300	36%	20523	0.0046	0.42	0.02	1.38	0	0	30	0.4	33	414	96	99.90%	99.995%
90	25500	0	100%	267	32%	19029	0.0038	0.30	0.01	1.01	0	0	30	0.3	27	368	85	99.92%	99.996%
100	25500	0	100%	240	29%	17551	0.0033	0.29	0.01	1.02	0	0	28	0.3	29	331	76	99.91%	99.996%
Zero Irrigation Case									0.01	0.23									

Average Daily Effluent Supply	698	kL		
Irrigation Water - Total N	130	mg/L	33120	kg/y
Irrigation Water - Total P	30	mg/L	7643	kg/y



Enterprise: JBS Townsville**Description:**

Nutrient Loading To Irrigated Land

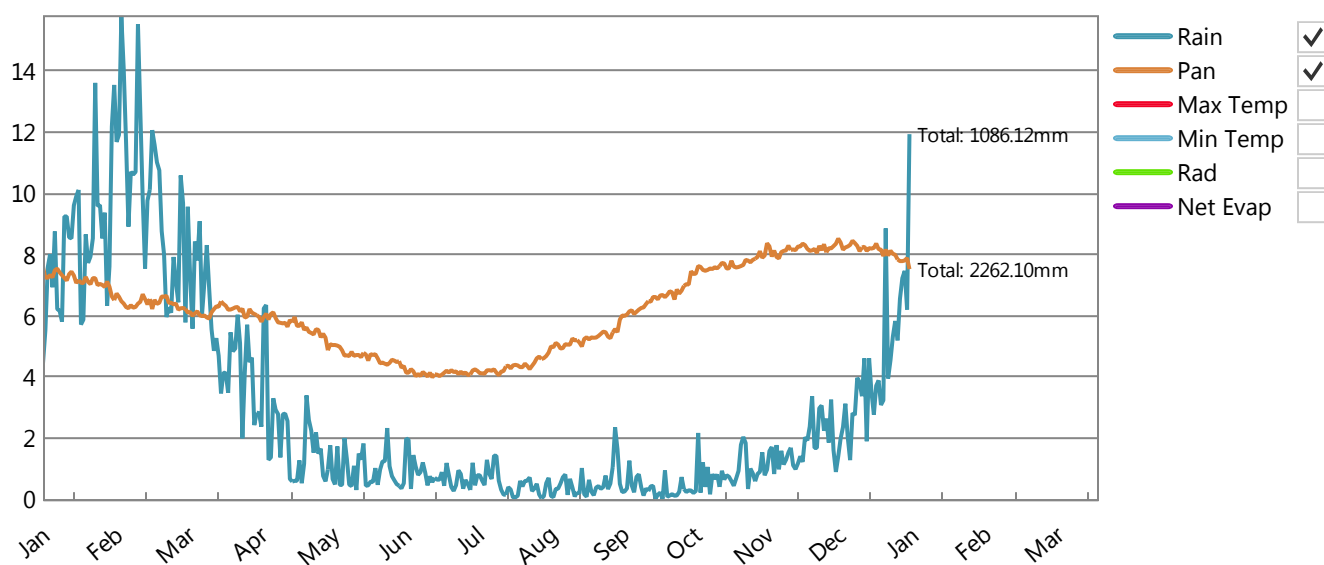
Client: JBS**MEDLI User:** Bio-Track P/L**Scenario Details:**

MEDLI REPORT - FULL RUN

medli

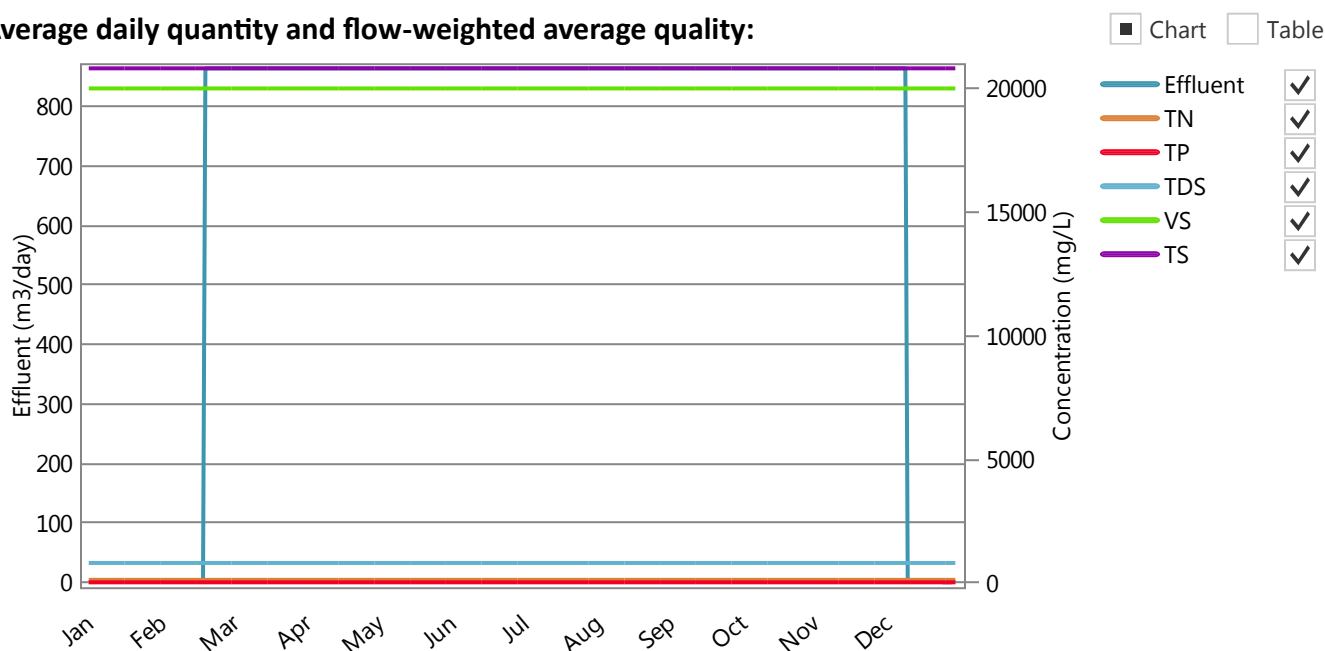
Climate Data: Stuart, -19.3°, 146.85°**Run Period: 01/01/1916 to 31/12/2015** 100 years, 0 days**Climate Statistics:**

	5th ▾	Percentile	50th Percentile	95th ▾	Percentile
Rainfall (mm/year)		459	1053		2062
Pan Evaporation (mm/year)		2019	2261		2456

Climate Data:☒ Chart ☐ Table☐ Monthly ☒ Daily**Daily Average Across Run Period**

DESCRIPTION

medli

Effluent type: JBS Townsville**Wastestream before any recycling or pretreatment****Average daily quantity and flow-weighted average quality:****Wastestream after any recycling and pretreatment if applicable**

Effluent quantity: **254988.25 m3/year** or 698.12 m3/day (Min-Max: 0.00 - 864.00)

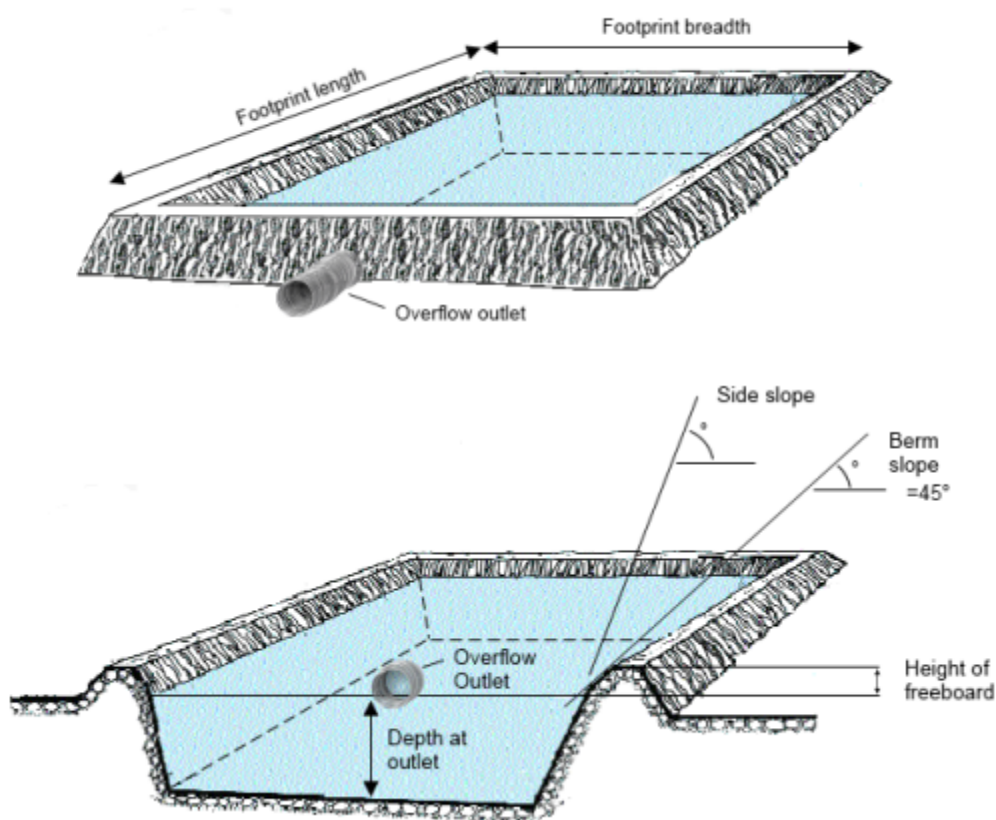
Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	130.00 (0.00 - 130.00)	33148.47 (33148.44 - 33148.57)
Total Phosphorus	30.00 (0.00 - 30.00)	7649.65 (7649.64 - 7649.67)
Total Dissolved Salts	813.00 (0.00 - 813.00)	207305.45 (207305.24 - 207306.06)
Volatile Solids	20000.00 (0.00 - 20000.00)	5099765.00 (5099760.00 - 5099780.00)
Total Solids	20813.00 (0.00 - 20813.00)	5307070.45 (5307065.24 - 5307086.06)

DESCRIPTION

Pond system: 1 facultative, aerobic or storage pond**Pond system details:**

	Pond 1
Maximum pond volume (m3)	25500.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	1.20
Maximum water surface area (m2)	21475.04
Pond footprint length (m)	146.54
Pond footprint width (m)	146.54
Pond catchment area (m2)	21475.04
Average active volume (m3)	6032.00

**Irrigation pump limits:**

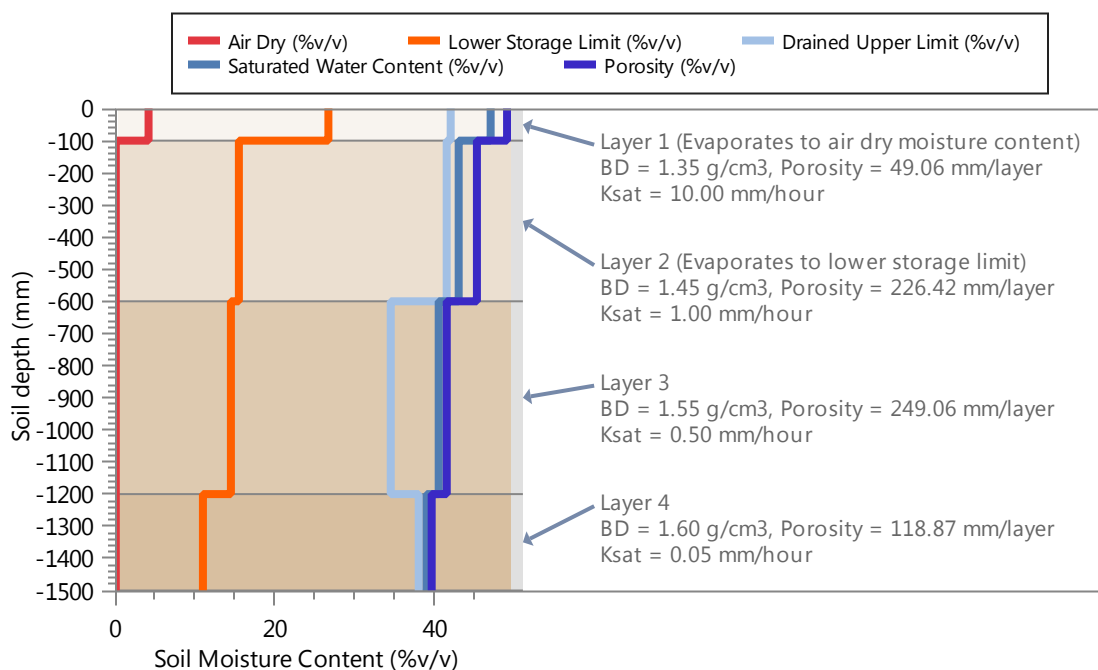
Minimum pump rate limit (ML/day)	0.00
Maximum pump rate limit (ML/day)	30.00

Shandying water:

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

Land: Irrigated Pasture**Area (ha): 50.00****Soil Type: Grey Clay- low drainage**, 1500.00 mm defined profile depth

Profile Porosity (mm)	643.40
Profile saturation water content (mm)	622.00
Profile drained upper limit (or field capacity) (mm)	570.50
Profile lower storage limit (or permanent wilting point) (mm)	224.20
Profile available water capacity (mm)	346.30
Profile limiting saturated hydraulic conductivity (mm/hour)	0.05
Surface saturated hydraulic conductivity (mm/hour)	10.00
Runoff curve number II (coefficient)	75.00
Soil evaporation U (mm)	6.00
Soil evaporation Cona (mm/sqrt day)	3.50

**Plant Data: Continuous Rhodes Grass Pasture-tropical**

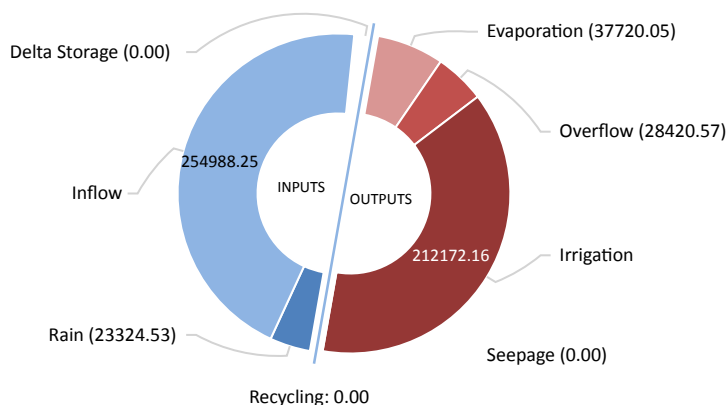
Average monthly cover (fraction) (minimum - maximum)	0.65 (0.58 - 0.70)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.9 x Pan coefficient 0.9)	0.81
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Maximum potential root depth in defined soil profile (mm)	1200.00
Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03

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Pond System Water Performance - Overflow: 1 facultative, aerobic or storage pond

Capacity of wet weather storage pond: **25500 m3**

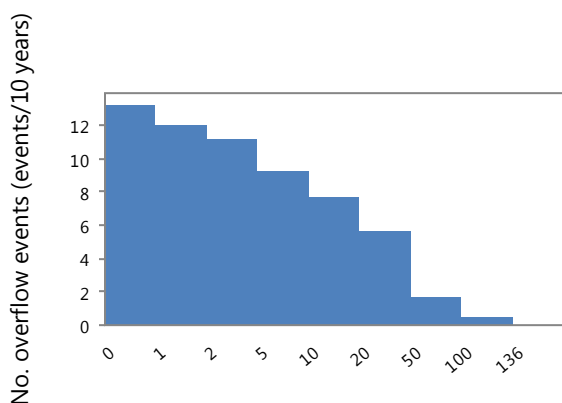
Pond System Water Balance (m3/year)



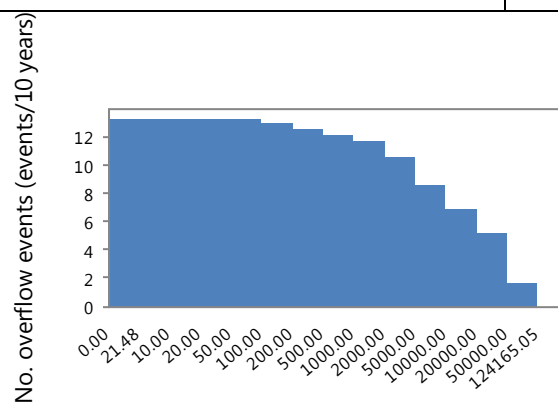
Name	Value
Rain	23324.53
Inflow	254988.25
Recycling	0.00
Evaporation	37720.05
Overflow	28420.57
Irrigation	212172.16
Seepage	0.00
Delta Storage	0.00

Overflow Diagnostics

Volume of overflow (m3/year)	28420.57
No. days pond overflows (days/year)	34.57
Average duration of overflow (days)	26.19
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.88
Probability of at least 90% reuse (fraction)	0.56



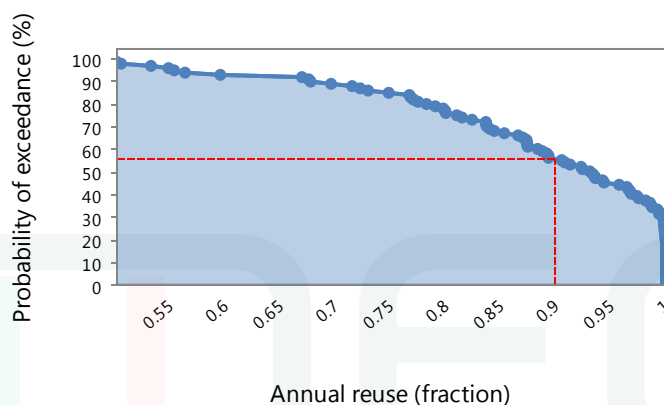
Overflow event duration exceeded (days)



Overflow volume exceeded (m3)

[Export plot](#)

[Export plot](#)

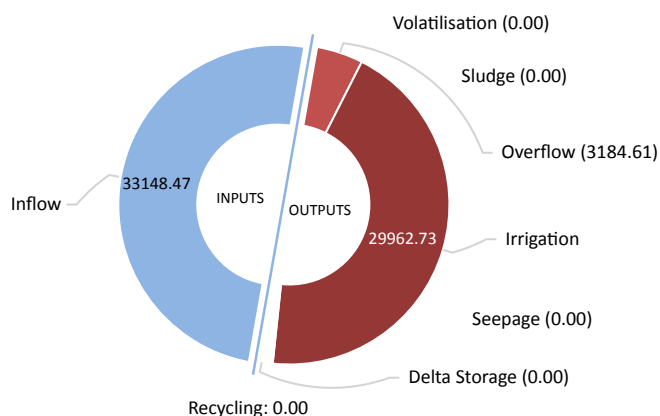


[Export plot](#)

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond

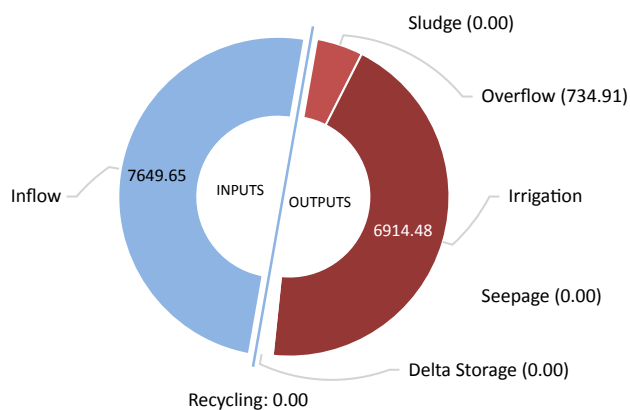
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



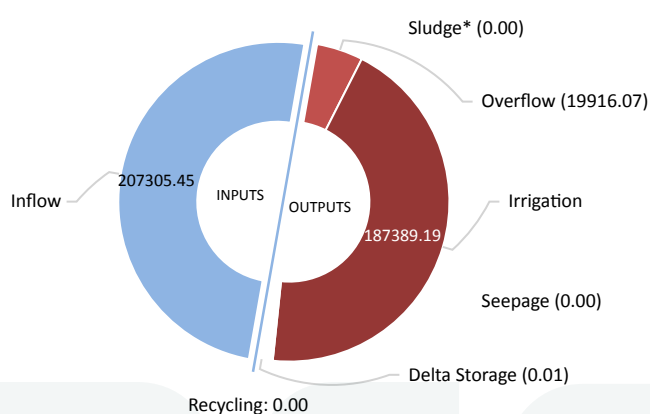
Name	Value
Inflow	33148.47
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	3184.61
Irrigation	29962.73
Seepage	0.00
Delta Storage	0.00

Phosphorus Balance (kg/year)



Name	Value
Inflow	7649.65
Recycling	0.00
Sludge	0.00
Overflow	734.91
Irrigation	6914.48
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	207305.45
Recycling	0.00
Sludge*	0.00
Overflow	19916.07
Irrigation	187389.19
Seepage	0.00
Delta Storage	0.01

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

Pond System Performance - Nutrient: 1 facultative, aerobic or storage pond**Pond Nutrient Concentrations and Salinity:**

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	118.96
Average phosphorus concentration of pond liquid (mg/L)	27.45
Average salinity of pond liquid (dS/m)	1.16

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	130001.89
Final phosphorus concentration of pond liquid (mg/L)	30000.44
Final salinity of pond liquid (dS/m)	1270.33

PERFORMANCE

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Irrigation Performance:**Water Use: (assumes 100% Irrigation Efficiency)**

Pond water irrigated (m3/year)	212172.16
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	212172.16
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	141.22
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	102.67
Average phosphorus concentration of irrigation water (mg/L)	32.59
Average salinity of irrigation water (dS/m)	1.38

Irrigation Diagnostics:

Proportion Days Irrigation Turned Off (fraction)	0.58
Proportion of Days rain prevents irrigation (fraction)	0.02
Proportion of Days water demand too small to trigger irrigation (fraction)	0.24
Proportion of Days pond volume below min. vol. for irrigation (fraction)	0.03
Proportion of Days irrigation occurs (fraction)	0.13



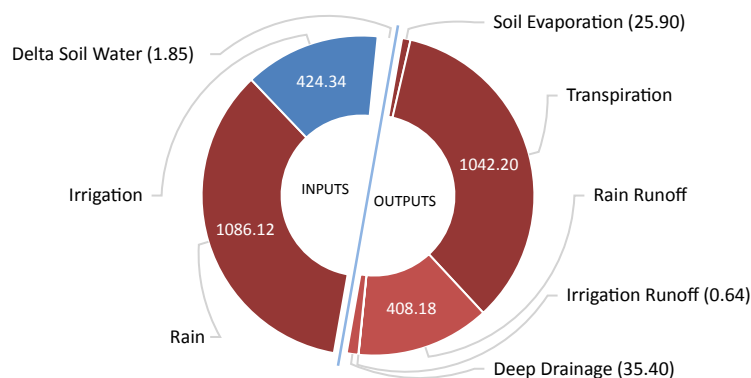
Land Performance - Soil Water

Paddock: Irrigated Pasture, 50 ha

Soil Type: Grey Clay- low drainage, 265.30 mm PAWC at maximum root depth

Land Water Balance (mm/year):

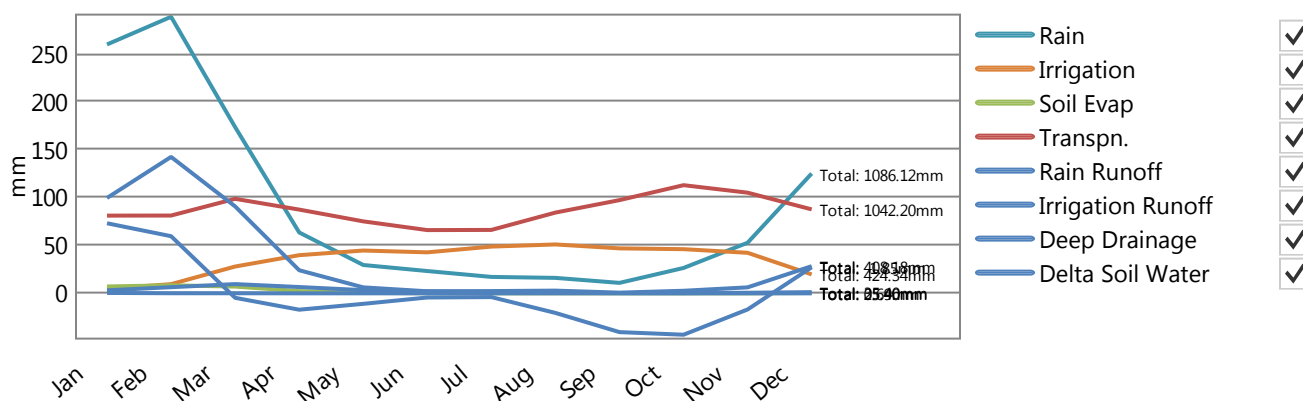
☒ mm/year ☐ % Total inputs



Name	Value
Rain	1086.12
Irrigation	424.34
Soil Evaporation	25.90
Transpiration	1042.20
Rain Runoff	408.18
Irrigation Runoff	0.64
Deep Drainage	35.40
Delta Soil Water	-1.85

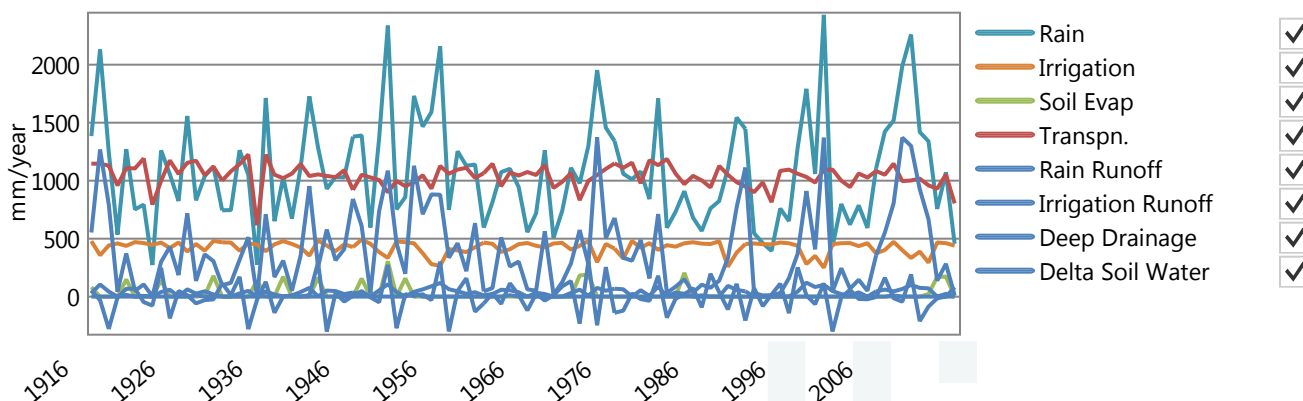
Average Monthly Totals (mm):

☒ Chart ☐ Table



Average Annual Totals (mm/year):

☒ Chart ☐ Table



Land Performance - Soil Nutrient

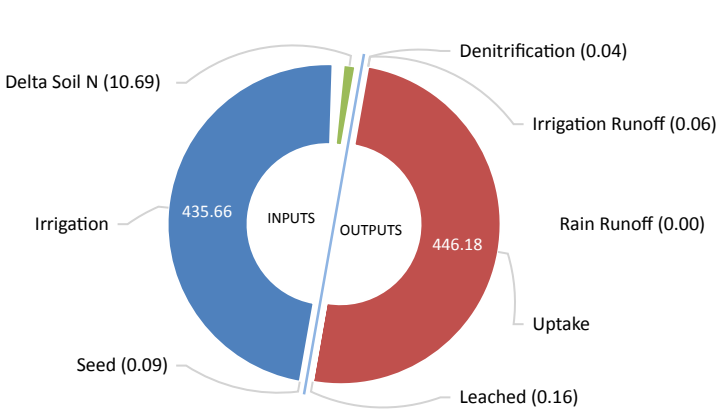
Paddock: Irrigated Pasture, 50 ha

Soil Type: Grey Clay- low drainage

Irrigation ammonium volatilisation losses (kg/ha/year): 163.60

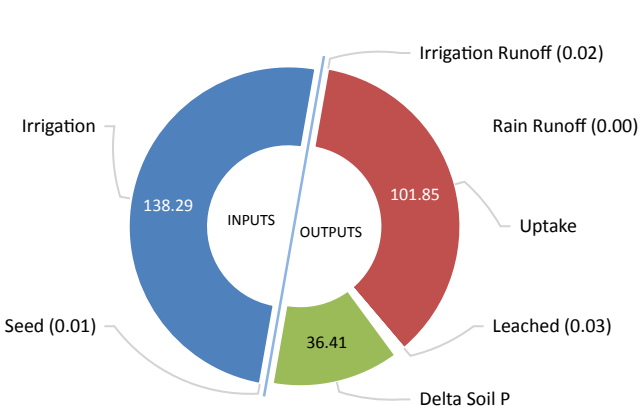
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.91

Land Nitrogen Balance (kg/ha/year)



Name	Value
Seed	0.09
Irrigation	435.66
Denitrification	0.04
Irrigation Runoff	0.06
Rain Runoff	0.00
Uptake	446.18
Leached	0.16
Delta Soil N	-10.69

Land Phosphorus Balance (kg/ha/year)



Name	Value
Seed	0.01
Irrigation	138.29
Irrigation Runoff	0.02
Rain Runoff	0.00
Uptake	101.85
Leached	0.03
Delta Soil P	36.41

PERFORMANCE

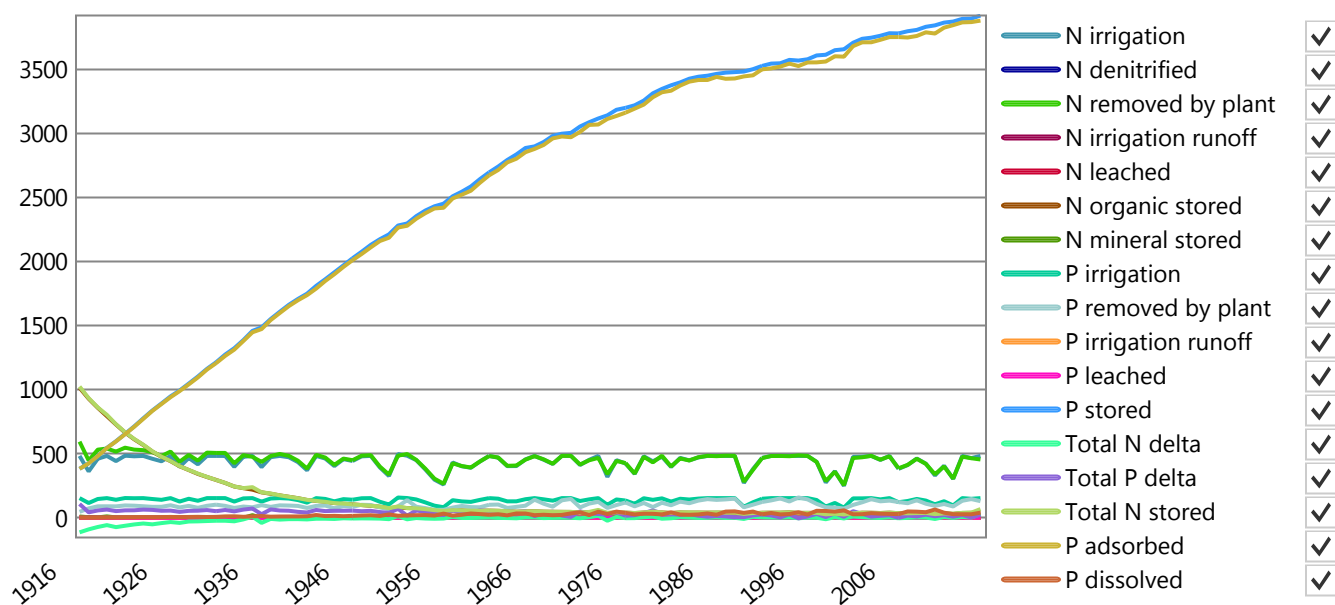


Land Performance - Soil Nutrient

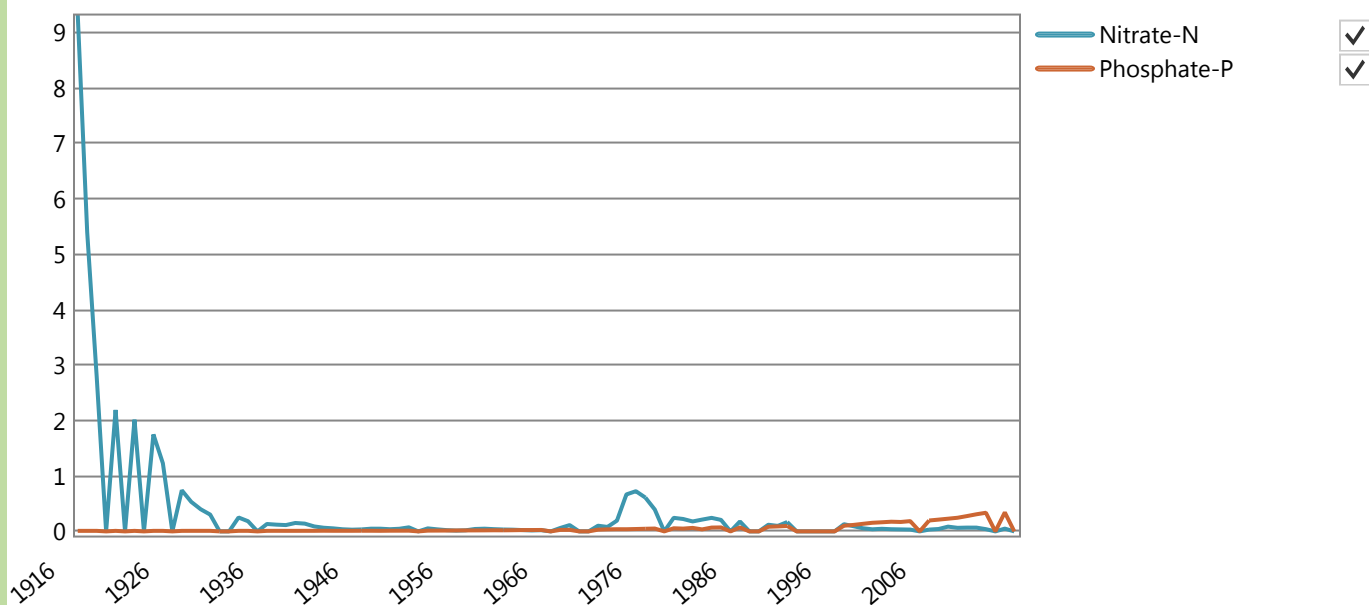
Paddock: Irrigated Pasture, 50 ha

Soil Type: Grey Clay- low drainage

Annual Nutrient Totals (kg/ha):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

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Plant Performance and Nutrients

Paddock: Irrigated Pasture, 50 ha

Soil Type: Grey Clay- low drainage

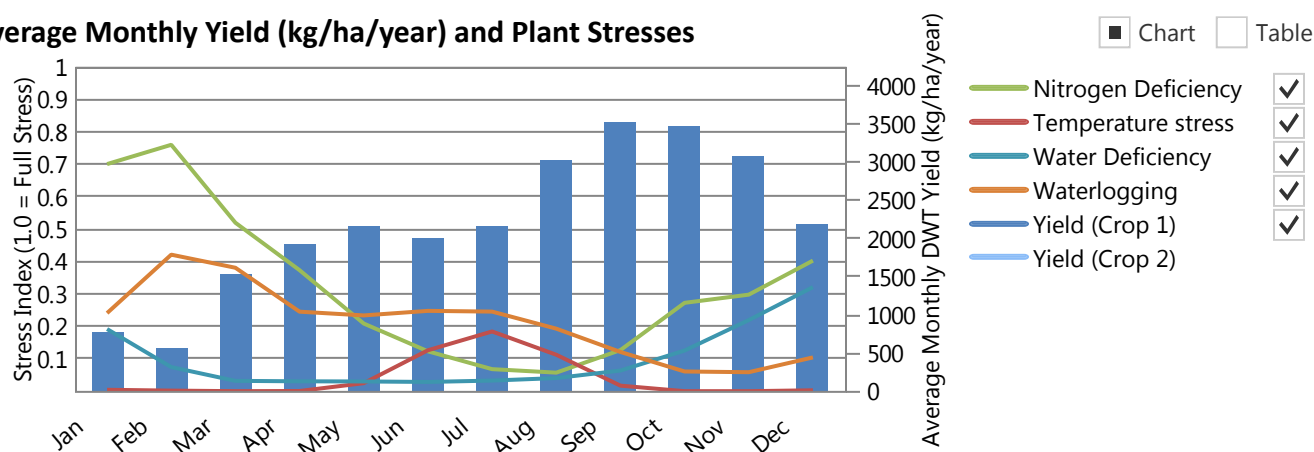
Plant: Continuous Rhodes Grass Pasture-tropical

Average annual shoot dry matter yield (kg/ha/year)	26527.04 (15773.07 - 32702.21)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.65 (0.58 - 0.70)
Average monthly root depth (mm) (minimum - maximum)	1176.04 (1101.64 - 1200.00)

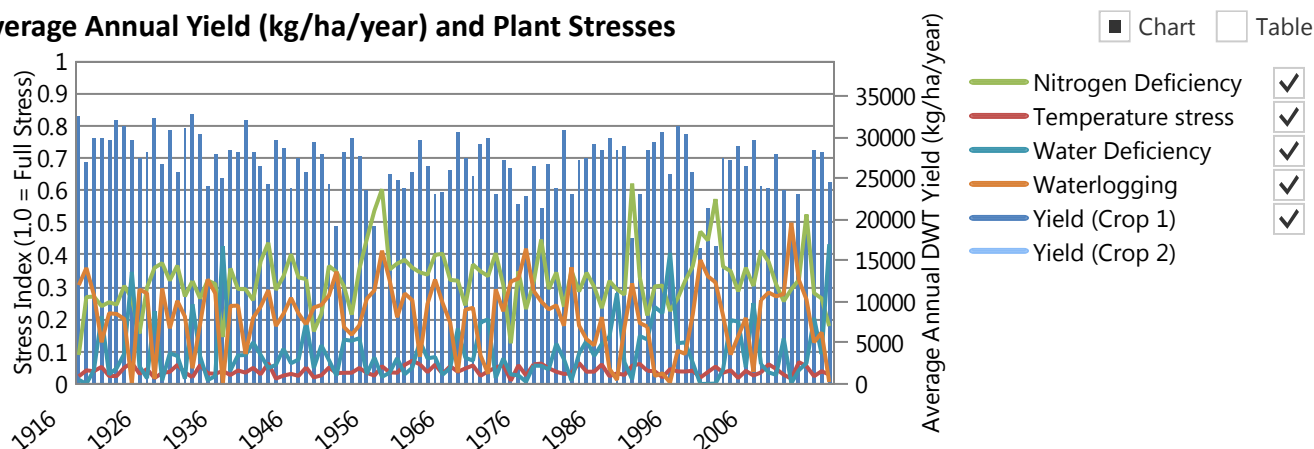
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/ha/year)	446.18 (254.11 - 593.48)
Average annual net phosphorus removed by plant uptake (kg/ha/year)	101.85 (45.95 - 158.11)
Average annual shoot nitrogen concentration (fraction dwt)	0.02 (0.01 - 0.02)
Average annual shoot phosphorus concentration (fraction dwt)	0.004 (0.001 - 0.005)

Average Monthly Yield (kg/ha/year) and Plant Stresses



Average Annual Yield (kg/ha/year) and Plant Stresses



No. of harvests/year: 4.53 (normal), 0.14 (forced by crop death due to water stress (0.13), waterlogging (0.01))

No. days without crop/year (days/year): 1.00 due to water stress (0.96), waterlogging (0.04)



Land Performance

Paddock: Irrigated Pasture, 50 ha

Soil Type: Grey Clay- low drainage

Plant: Continuous Rhodes Grass Pasture-tropical

Salt tolerance	Tolerant
Salinity threshold EC sat. ext. (dS/m)	7.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03
No. years assumed for leaching to reach steady-state (years)	10.00

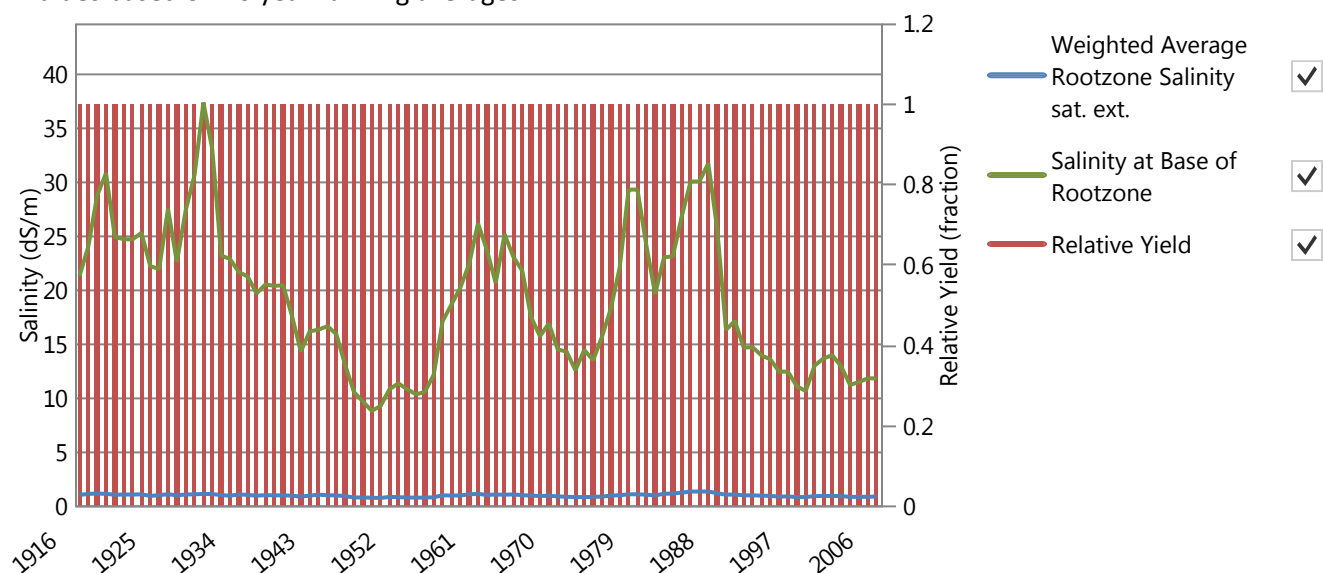
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.55
Salt added by rainfall (kg/ha/year)	130.17
Average annual effluent salt added & leached at steady state (kg/ha/year)	3877.47
Average leaching fraction based on 10 year running averages (fraction)	0.25
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.02
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	19.10
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average Annual Rootzone Salinity and Relative Yield:

☒ Chart ☐ Table

All values based on 10 year running averages



PERFORMANCE

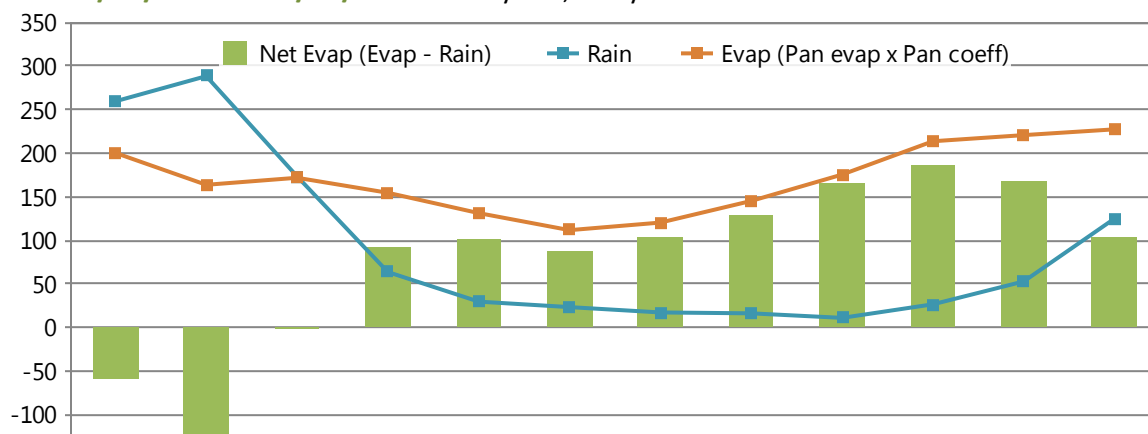


Sustainability Diagnostics: JBS Townsville

Averaged Historical Climate Data Used in Simulation (mm)

Location: **Stuart, -19.3°, 146.85°**

Run Period: **01/01/1916 to 31/12/2015** 100 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	259.6	288.4	173.4	63.5	29.6	23.3	17.1	16.1	10.9	26.5	52.8	125.0	1086.1
Evap	200.3	163.7	171.8	154.5	131.2	111.6	120.3	145.2	175.4	213.7	220.8	227.4	2035.9
Net Evap	-59.3	-124.7	-1.6	91.0	101.6	88.4	103.2	129.0	164.5	187.2	168.0	102.4	949.8
Net Evap/day	-1.9	-4.4	-0.1	3.0	3.3	2.9	3.3	4.2	5.5	6.0	5.6	3.3	2.6

DIAGNOSTICS

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Sustainability Diagnostics: JBS Townsville

Pond System: 1 facultative, aerobic or storage pond

JBS Townsville - 254988.25 m3/year or 698.12 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 361.25 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	130.00 (0.00 - 130.00)	33148.47 (33148.44 - 33148.57)
Total Phosphorus	30.00 (0.00 - 30.00)	7649.65 (7649.64 - 7649.67)
Total Dissolved Salts	813.00 (0.00 - 813.00)	207305.45 (207305.24 - 207306.06)
Volatile Solids	20000.00 (0.00 - 20000.00)	5099765.00 (5099760.00 - 5099780.00)
Total Solids	20813.00 (0.00 - 20813.00)	5307070.45 (5307065.24 - 5307086.06)

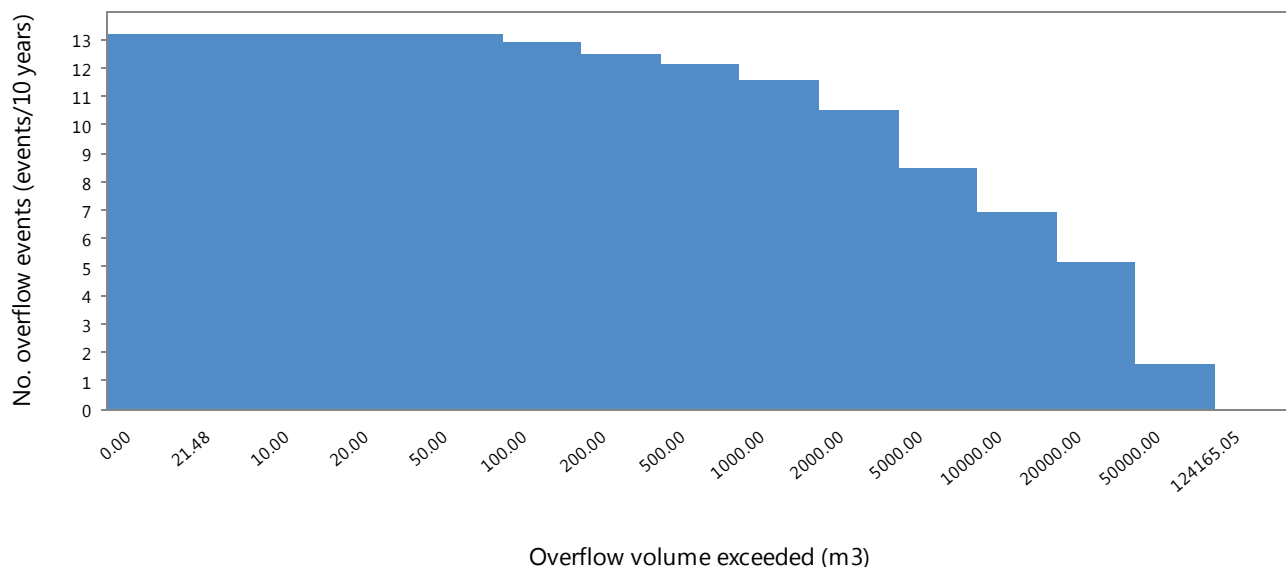
Last pond (Wet weather store): 25500.00 m3

Theoretical hydraulic retention time (days)	36.53
Average volume of overflow (m3/year)	28420.57
No. overflow events per year exceeding threshold* of 21.48 m3 (no./year)	1.32
Average duration of overflow (days)	26.19
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	0.88
Probability of at least 90% effluent reuse (fraction)	0.56
Average salinity of last pond (dS/m)	1.16
Salinity of last pond on final day of simulation (dS/m)	1270.33
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

☒ Chart ☐ Table



[Export plot](#)



Sustainability Diagnostics: JBS Townsville

Irrigation Information

Irrigation: 50 ha total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	212172.16	4243.44
Total nitrogen applied (kg)	21782.90	435.66
Total phosphorus applied (kg)	6914.48	138.29
Total salts applied (kg)	187389.37	3747.79

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is turned off (fraction)	0.58
Proportion of Days irrigation is prevented when triggered (fraction)	0.05
Proportion of Days water demand is too small to trigger irrigation (fraction)	0.24
Proportion of Days irrigation occurs (fraction)	0.13

Sustainability Diagnostics: JBS Townsville

Paddock Land: Irrigated Pasture: 50 ha

Irrigation: High Travelling Irrigator with 0.3% ammonium loss during irrigation

Irrigation triggered when soil water deficit reaches 40.00 mm and rainfall is less than or equal to 20.00 mm
Irrigate up to a soil water content of drained upper limit plus 0.00 mm
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 7 days must be skipped between irrigation events

Soil Water Balance (mm): Grey Clay- low drainage, 265.30 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	259.6	288.4	173.4	63.5	29.6	23.3	17.1	16.1	10.9	26.5	52.8	125.0	1086.1
Irrigation	4.8	9.6	28.0	39.8	44.6	42.8	48.8	51.0	46.9	46.1	42.3	19.7	424.3
Soil Evap	7.2	8.4	7.0	2.4	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.3	25.9
Transpn.	81.1	81.2	98.6	87.3	75.1	66.0	66.2	84.2	97.2	112.8	105.0	87.6	1042.2
Rain Runoff	99.5	142.3	90.7	24.1	6.2	2.2	2.4	2.8	0.7	2.7	6.2	28.3	408.2
Irr. Runoff	0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
Drainage	3.1	6.4	9.6	6.6	3.3	2.1	1.3	0.5	0.3	0.2	0.6	1.3	35.4
Delta	73.1	59.6	-4.7	-17.1	-10.9	-4.3	-3.9	-20.4	-40.4	-43.2	-16.8	27.2	-1.8

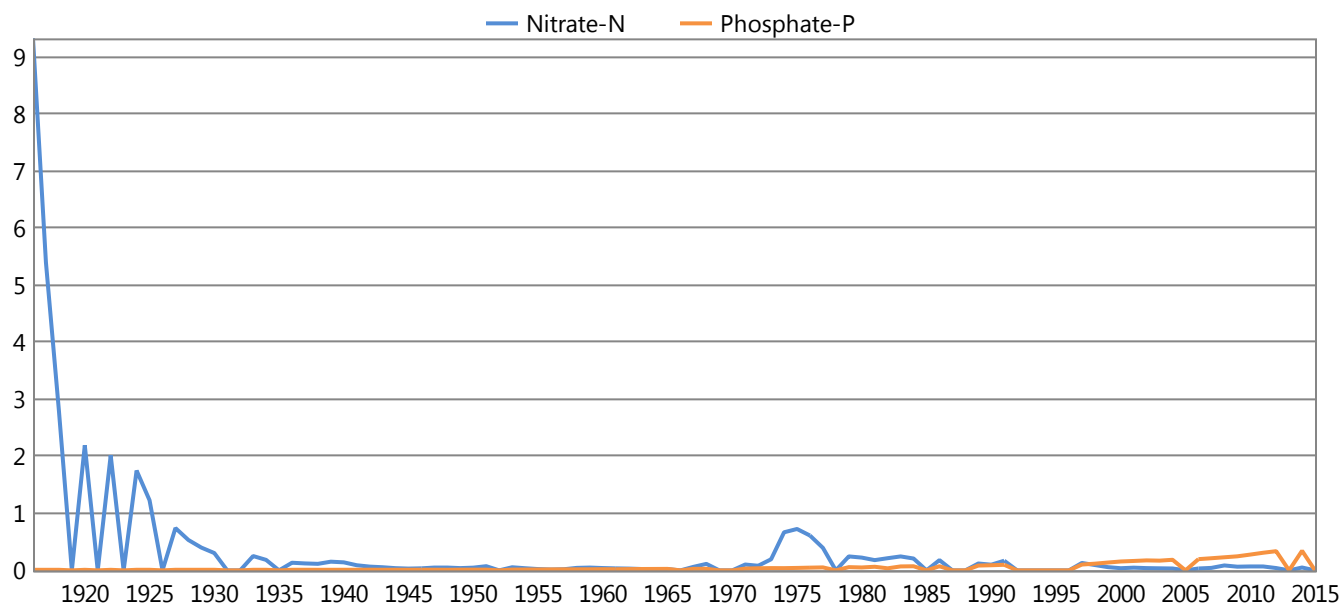
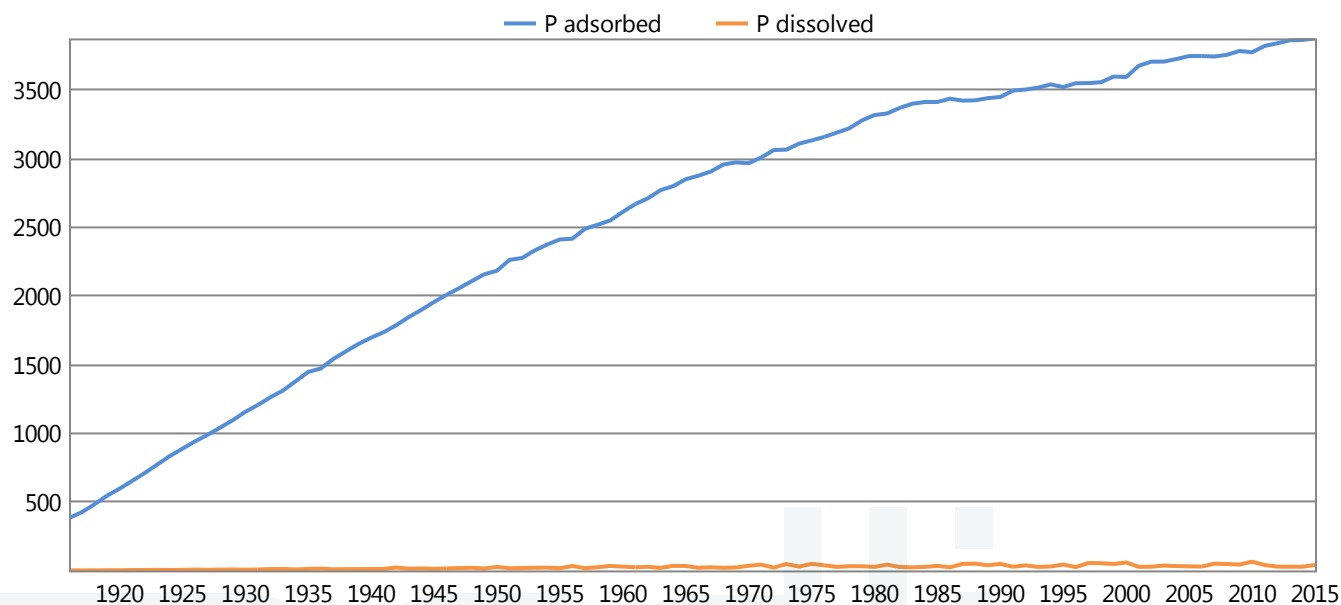
Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/ha/year)	435.66
Average annual soil nitrogen removed by plant uptake (kg/ha/year)	446.18
Average annual soil nitrogen removed by denitrification (kg/ha/year)	0.04
Average annual soil nitrogen leached (kg/ha/year)	0.16
Average annual nitrate-N loading to groundwater (kg/ha/year)	0.16
Soil organic-N kg/ha (Initial - Final)	1080.00 - 40.32
	56.75 - 27.13
Average nitrate-N concentration of deep drainage (mg/L)	0.46
Max. annual nitrate-N concentration of deep drainage (mg/L)	9.32

Soil Phosphorus Balance

Average annual effluent phosphorus added (kg/ha/year)	138.29
Average annual soil phosphorus removed by plant uptake (kg/ha/year)	101.85
Average annual soil phosphorus leached (kg/ha/year)	0.03
Dissolved phosphorus (kg/ha) (Initial - Final)	0.06 - 39.60
Adsorbed phosphorus (kg/ha) (Initial - Final)	274.67 - 3876.13
Average phosphate-P concentration in rootzone (mg/L)	8.09
Average phosphate-P concentration of deep drainage (mg/L)	0.08
Max. annual phosphate-P concentration of deep drainage (mg/L)	0.34
Design soil profile storage life based on average infiltrated water phosphorus concn. of 12.55 mg/L (years)	30.16



Sustainability Diagnostics: JBS Townsville**Paddock Land: Irrigated Pasture: 50 ha****Irrigation: High Travelling Irrigator with 0.3% ammonium loss during irrigation****Annual nutrient leachate concentration (mg/L)****Annual Phosphate-P in soil (kg/ha)**

DIAGNOSTICS

Sustainability Diagnostics: JBS Townsville

Paddock Plant Performance: Irrigated Pasture: 50 ha

Average Plant Performance (Minimum - Maximum): Continuous Rhodes Grass Pasture-tropical

Average annual shoot dry matter yield (kg/ha/year)	26527.04 (15773.07 - 32702.21)
Average monthly plant (green) cover (fraction)	0.65 (0.58 - 0.70)
Average monthly crop factor (fraction)	0.53 (0.47 - 0.57)
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Average monthly root depth (mm)	1176.04 (1101.64 - 1200.00)
Average number of normal harvests per year (no./year)	4.53 (2.00 - 6.00)
Average number of normal harvests for last five years only (no./year)	4.00
Average number of crop deaths per year (no./year)	0.14 (0.00 - 1.00)
Average number of crop deaths for last five years only (no./year)	0.40
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.32 (0.09 - 0.62)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.04)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.18 (0.01 - 0.37)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.10 (0.03 - 0.32)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.21 (0.06 - 0.42)
No. days without crop/year (days)	1.00

Soil Salinity - Plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts

All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.55
Salt added by rainfall (kg/ha/year)	130.17
Average annual effluent salt added & leached at steady state (kg/ha/year)	3877.47
Average leaching fraction based on 10 year running averages (fraction)	0.25
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.02
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	19.10
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00



Run Messages

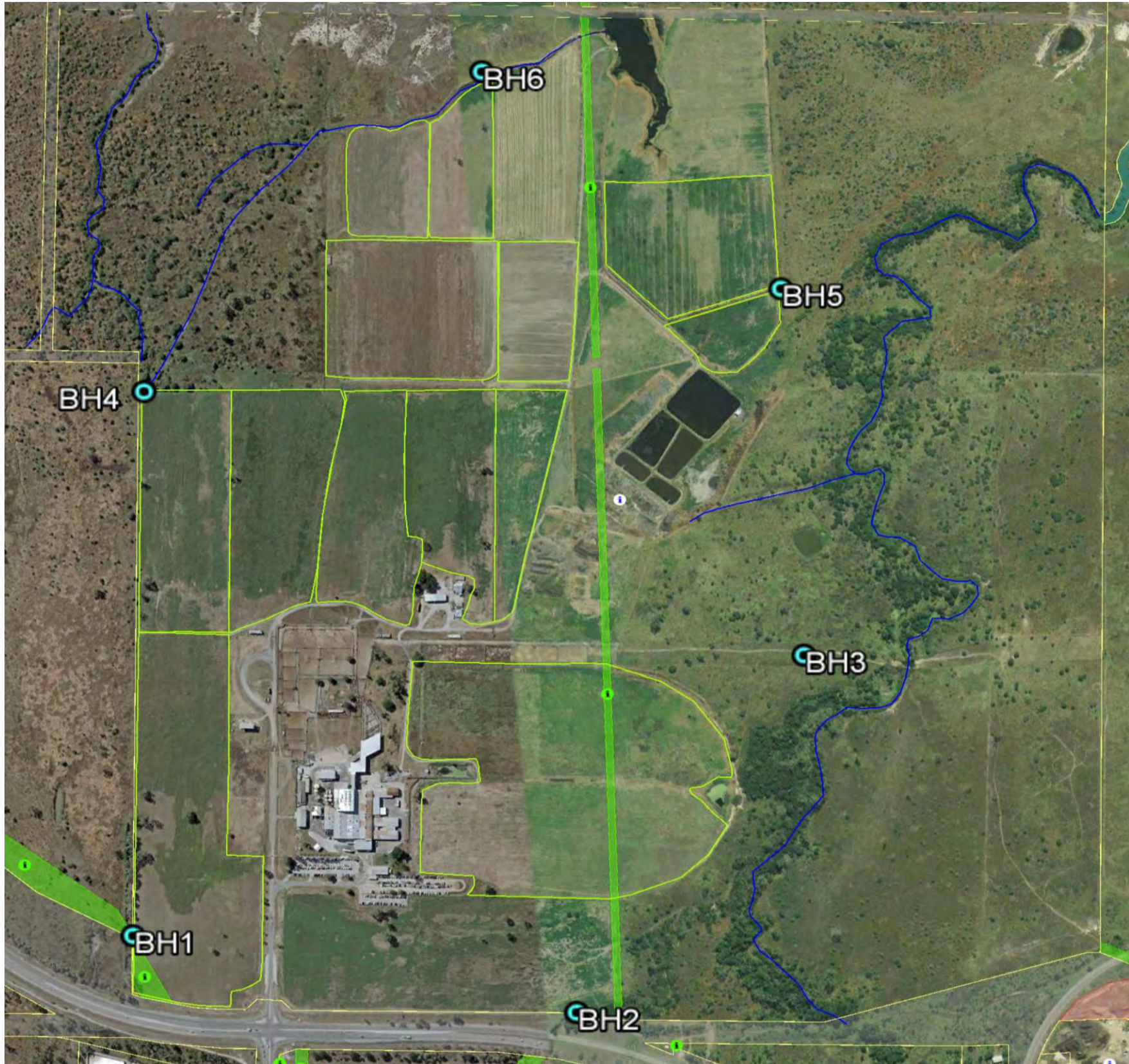
Messages generated when the scenario was run:

WARNING: Irrigation water salinity exceeds 10 dS/m. Leaf scorching and yield reduction likely. Careful irrigation management needed.

Full run chosen

TABLE 1: Soil Profile Description									
Date of Field Work		9/5/2018		Sampling Method	90 mm power auger				
Field Staff		Peter Edmiston							
Name	BH1	BH2	BH3	BH4	BH5	BH6			
Relief/ Slope	Level plain	Level plain	Level plain	Level plain	Level plain	Level plain			
Landform Pattern	Delta	Delta	Delta	Delta	Delta	Delta			
Lf. Morphology	Simple-slope	Simple-slope	Simple-slope	Simple-slope	Simple-slope	Simple-slope			
Lf. Elements	Plain	Plain	Plain	Plain	Plain	Plain			
Drainage Class	Imperfectly drained	Imperfectly drained	Imperfectly drained	Imperfectly drained	Imperfectly drained	Imperfectly drained			
Microrelief	No microrelief	No microrelief	No microrelief	No microrelief	No microrelief	No microrelief			
Soil Order	Sodosol	Sodosol	Sodosol	Sodosol	Sodosol	Sodosol			
Sub Order	Natric	Natric	Natric	Natric	Natric	Natric			
Profile Placement	depositional	depositional	depositional	depositional	depositional	depositional			
Lat (WGS84)	-19.335022°	-19.336815°	-19.331401°	-19.326486°	-19.325505°	-19.321642°			
Long.	146.850899°	146.857647°	146.861692°	146.851889°	146.861878°	146.857568°			
m									
Surface	firm	firm	firm	firm	firm	firm			
0.0	grey brown silty clay	grey brown sandy clay, disturbed	dark grey silty clay	dark grey silty clay	dark grey silty clay	brown sandy clay loam			
0.2	yellow brown sandy clay								
0.4		yellow brown sandy clay		dark grey silty clay		grey, medium clay	dark grey silty clay	dark brown clay, moist	
0.6									
0.8									
1.0									
1.2									
1.4									
1.6									
1.8									
2.0									
2.2									
2.4									
2.6									
2.8									
3.0									
3.2									
3.4									
3.6									
3.8	sandy clay, increasing sand	yellow brown clay, moist	dark brown clay, moist	brown clay, moist	dark brown clay, moist				
4.0	moist, yellow brown sandy clay						----Terminated ----		
4.2									
4.4	----Terminated ----								
4.5									
4.8									
5.0									

Bore Locations





Certificate of Analysis

Signatory:

Phone: +617 3289 7179 Bio-Track Pty Ltd ABN 91 056 237 275

Test Code/Name		[179] Phosphorus Olsen 1:20	
Lab Reference (LR)	140518.489	Client Name	BIO-TRACK PTY LTD
SampleID	All Samples	Client Contact	Peter Edmiston
		Project Name	JB5 - Wastewater Irrigation
Report Date	25/05/2018	Job Number	
Sample Received Date	11/05/2018	Order Number	
Sample Disposal Date	13/07/2018	Chain of Custody	
Sample Packaging	Plastic Bag	Client Email	
Temperature	Ambient	Client Address	781 Mount Glorious Road Highvale Brisbane Queensland

Analytical Method: As per Olsen-P (9C), Colwell-P (9B), Soil Chemical Methods - Australasia, Raymont & Lyons, 2001.

S#	SampleID	Olsen P mg P/kg
1	BH2 200	52
2	BH2 500	4
3	BH2 600	2
4	BH3 4000	<1
5	BH5 4000	7
6	BH5 4500	6

CERTIFICATE OF ANALYSIS



Analysis By: Bio-Track Pty Ltd
ABN 91 056 237 275
Mt. Glorious Road
Highvale, Brisbane, Australia, 4520
Ph. 07 3289 7179 Fx. 07 3289 7155

DATE OF REPORT 15 MAY 2018
CLIENT NAME Peter Edmiston c/o BIO-TRACK PTY LTD
CLIENT ADDRESS 781 Mount Glorious Road Highvale Brisbane
PROJECT NAME JB5 - Wastewater Irrigation
SAMPLING DATE NUMBER OF SAMPLES 6 SAMPLE TYPE: Soil/Solid
PACKAGING Plastic Bag ** SAMPLES DISPOSED ON 13/07/2018
DATE RECEIVED 14/05/2018 11:43:55 AM LAB REF. LR140518.491

Page 1 of 1 Report Pages.

METHODOLOGY: EC pH Cl as 1:5 air dried soil in water, 30 minute rolling shake, Cl by ion selective electrode. Na K Mg Ca Fe Al S as 1:20 soil dried soil in 1 N NH₄Cl, 60 minute rolling shake, Na K Mg Ca Fe Al S measured by ICP OES CEC (cation exchange capacity) as the sum of extracted cations (no pretreatment for soluble salts), SAR (sodium adsorption ratio) as $\text{Na} / ((\text{Ca} + \text{Mg}) / 2)^{0.5}$, %Na as Na% of CEC. (meq/100 = milli-equivalents/100 g soil)

SAMPLE ID	EC	pH	Na	K	Ca	Mg	Fe	Al	Cl	S	ECEC	SAR	%Na	Ca:Mg
m depth	dS/m		meq/100	meq/100	meq/100	meq/100	mg/kg	mg/kg	mg/kg	mg/kg	meq/100	ratio	ratio	ratio
BH2 200-	0.30	5.8	2.1	0.4	6.9	6.5	4	2	220	46	16.0	0.80	13.0	1.1
BH2 500-	1.29	7.6	11.3	0.3	18.4	17.9	2	2	1647	32	48.0	2.65	23.5	1.0
BH2 600-	1.08	8.4	9.5	0.2	20.9	14.6	1	3	1351	24	45.2	2.24	20.9	1.4
BH3 4000-	0.75	8.5	7.6	0.2	12.7	13.2	1	1	901	28	33.6	2.11	22.5	1.0
BH5 4000-	0.92	8.2	6.8	0.3	16.0	12.4	2	3	1101	18	35.6	1.81	19.1	1.3
BH5 4500-	0.73	9.0	9.8	0.2	13.8	8.8	2	2	749	42	32.6	2.93	30.2	1.6

Signatory

For and behalf of Bio-Track Pty Ltd



Certificate of Analysis

Signatory:

Phone: +617 3289 7179 Bio-Track Pty Ltd ABN 91 056 237 275

Test Code/Name	[54] Nitrate+nitrite		
Lab Reference (LR)	140518.490	Client Name	BIO-TRACK PTY LTD
SampleID	All Samples	Client Contact	Peter Edmiston
		Project Name	JB5 - Wastewater Irrigation
Report Date	25/05/2018	Job Number	
Sample Received Date	11/05/2018	Order Number	
Sample Disposal Date	13/07/2018	Chain of Custody	
Sample Packaging	Plastic Bag	Client Email	
Temperature	Ambient	Client Address	781 Mount Glorious Road Highvale Brisbane Queensland

Analytical Method: 1:5 in 0.01M CaCl₂. 2 hour rolling shake. Measurement by ICP.

S#	SampleID	Nitrate mg/kg
1	BH2 200	3.2
2	BH2 500	0.1
3	BH2 600	0.2
4	BH3 4000	0.1
5	BH5 4000	0.3
6	BH5 4500	<0.1



TropWATER Analytical Services

James Cook University Townsville 4811 QLD Australia

Tel: 07 4781 4262 Fax: 07 4781 5589 Email: actfr.laboratory@jcu.edu.au

Certificate of Analysis

Client Details

Client Name: JBS Swift
Postal Address: PO Box 1160
 AITKENVALE QLD 4810
Attention: Trevor Govindsamy
Telephone: 07 4720 8029
Email: Trevor.Govindsamy@jbssa.com.au

Laboratory Contact

Michelle Tink
 (MRACI C.Chem.)
 Laboratory Manager
 Phone: 07 4781 5214
 Fax: 07 4781 5589
 Email: michelle.tink@jcu.edu.au

Analysis Results:

Analysis	Unit	Overflow 27/03/2018 J18-0094/1
Oil & Grease	mg/L	<5
Nitrite	µg N/L	<1
Total Nitrogen	mg N/L	4.1
Total Kjeldahl Nitrogen	mg N/L	4.1
Ammonia	mg N/L	1.1
Total Phosphorus	mg P/L	4.66
Filterable Reactive Phosphorus	mg P/L	4.51
Faecal coliforms	cfu/100mL	3,600
Volatile Fatty Acids	mg/L	18
Alkalinity	mg CaCO ₃ /L	74
Biological Oxygen Demand	mg/L	10
pH		6.93
Electrical Conductivity	µS/cm	230
Chemical Oxygen Demand	mg/L	94
Total Dissolved Solids	mg/L	230
Total Suspended Solids	mg/L	11

Comment:

Patrick Cunningham
 Laboratory Technician
TropWATER

Michelle Tink MRACI C.Chem
 Laboratory Manager
TropWATER

APPENDIX 3: HARVESTED HAY RECORDS



TropWATER Analytical Services

James Cook University Townsville 4811 QLD Australia

Tel: 07 4781 4262 Fax: 07 4781 5589 Email: actfr.laboratory@jcu.edu.au

Certificate of Analysis

Client Details

Client Name: JBS Swift
Postal Address: PO Box 1160
AITKENVALE QLD 4810
Attention: Trevor Govindsamy
Telephone: 07 4720 8029
Email: Trevor.Govindsamy@jbssa.com.au

Laboratory Contact

Michelle Tink
(MRACI C.Chem.)
Laboratory Manager
Phone: 07 4781 5214
Fax: 07 4781 5589
Email: michelle.tink@jcu.edu.au

Analysis Results:

Analysis	Unit	Irrigation Area 1 28/11/2017 J17-0346/1	Irrigation Area 2 28/11/2017 J17-0346/2	Irrigation Area 3 28/11/2017 J17-0346/3	Irrigation Area 4 28/11/2017 J17-0346/4
Phosphorus	%	0.33	0.47	0.41	0.33
Nitrogen	%	1.20	1.14	1.68	2.38
Potassium	%	1.40	1.74	1.49	1.68
Sodium	%	1.83	1.55	1.99	2.20

Analysis	Unit	Irrigation Area 5 28/11/2017 J17-0346/5	Irrigation Area 6 28/11/2017 J17-0346/6
Phosphorus	%	0.32	0.27
Nitrogen	%	3.44	1.48
Potassium	%	2.13	1.94
Sodium	%	3.02	1.66

Comment:

Patrick Cunningham
Laboratory Technician
TropWATER

Michelle Tink MRACI C.Chem
Laboratory Manager
TropWATER

Monthly Bale Count - JBS Swift

Jan 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1							0	0
I2							0	0
I3							0	0
I4							0	0
I5							0	0
I6							0	0
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		0	0	0	0	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	0	0	0		
Total Weight Dry Matter (t)		0					0	0

Monthly Bale Count - JBS Swift

Feb 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1							0	0
I2	10.02.17	52		132	140		324	61
I3	23.02.17	235		104	61		400	88
I4	20.02.17	192					192	46
I5	15.02.17	172					172	41
I6	28.02.17	91					91	22
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		742	0	236	201	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		178	0	54	26	0		
Total Weight Dry Matter (t)		259					1179	259

Monthly Bale Count - JBS Swift

March 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1							0	0
I2							0	0
I3							0	0
I4							0	0
I5							0	0
I6							0	0
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4	06.03.17	78					78	19
F5							0	0
F6	07.03.17	50					50	12
F7							0	0
Qty Sub Total		128	0	0	0	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		31	0	0	0	0		
Total Weight Dry Matter (t)		31					128	31

Monthly Bale Count - JBS Swift

April 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1							0	0
I2	06.04.17			70	280		350	53
I3	24.04.17				126		126	17
I4	05.04.17			46	74		120	20
I5	06.04.17				40		40	5
I6							0	0
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		0	0	116	520	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	27	68	0		
Total Weight Dry Matter (t)		95					636	95

Monthly Bale Count - JBS Swift

May 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1	28.05.17			44	186		230	35
I2							0	0
I3							0	0
I4							0	0
I5							0	0
I6							0	0
I7							0	0
I8							0	0
F1							0	0
F2	02.05.17	20				70	90	29
F3	02.05.17					180	180	61
F4	08.05.17				205		205	27
F5							0	0
F6							0	0
F7	07.05.17					115	115	39
Qty Sub Total		20	0	44	391	365		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		5	0	10	51	124		
Total Weight Dry Matter (t)		190					820	190

Monthly Bale Count - JBS Swift

June 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1							0	0
I2	19.06.17				175		175	23
I3	26.06.17				140		140	18
I4	07.06.17			44			44	10
I5	07.06.17				120		120	16
I6	05.06.17				58		58	8
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		0	0	44	493	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	10	65	0		
Total Weight Dry Matter (t)		75					537	75

Monthly Bale Count - JBS Swift

July 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1	31.07.17				168		168	22
I2							0	0
I3							0	0
I4							0	0
I5							0	0
I6	25.07.17				46		46	6
I7	04.07.17				470		470	62
I8							0	0
F1							0	0
F2	26.07.17			54	35		89	17
F3	25.07.17			17	18		35	6
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		0	0	71	737	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	16	97	0		
Total Weight Dry Matter (t)		113					808	113

Monthly Bale Count - JBS Swift

Aug 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1							0	0
I2	14.08.17				269		269	35
I3							0	0
I4	08.08.17				100		100	13
I5	08.08.17				100		100	13
I6							0	0
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6	14.08.17				72		72	9
F7	08.08.17				84		84	11
Qty Sub Total		0	0	0	625	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	0	82	0		
Total Weight Dry Matter (t)		82					625	82

Monthly Bale Count - JBS Swift

Sept 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1	23.09.17			80	56		136	26
I2							0	0
I3	04.09.17				210		210	28
I4							0	0
I5							0	0
I6	20.09.17				68		68	9
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		0	0	80	334	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	18	44	0		
Total Weight Dry Matter (t)		62					414	62

Monthly Bale Count - JBS Swift

Oct 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1							0	0
I2	09.10.17				171		171	22
I3	30.10.17				272		272	36
I4							0	0
I5							0	0
I6							0	0
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		0	0	0	443	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	0	58	0		
Total Weight Dry Matter (t)		58					443	58

Monthly Bale Count - JBS Swift

Nov 2017

Paddock Code	Date Cut	Qty Silage	Qty 5x4ft	Qty 4x4ft	Qty 3x4ft	Qty Square	Paddock Totals (Bales)	Dry Matter Totals (t)
I1	14.11.17			20	282		302	42
I2							0	0
I3							0	0
I4	04.11.17				215		215	28
I5	04.11.17				215		215	28
I6	04.11.17				100		100	13
I7							0	0
I8							0	0
F1							0	0
F2							0	0
F3							0	0
F4							0	0
F5							0	0
F6							0	0
F7							0	0
Qty Sub Total		0	0	20	812	0		
Avg Weight Dry Matter (kg)		240	426	230	131	340		
Sub Weight Dry Matter (t)		0	0	5	107	0		
Total Weight Dry Matter (t)		111					832	111

APPENDIX 4: SPECIFICATION OF DAM VOLUMES & FIELD AREAS



Tailwater

Stock 1

Flood 1

Flood 4

Flood 3

Flood 2

Flood 7

Flood 5

Flood 6

Flood 8

Spray 1

Spray 2

Spray 3

Spray 4

Spray 5

6

4

5

2

3

1

Sludge

Stock 3

Spray 6

Partly Sprayed

F.Flush

Stock 2

Spray 7

	Irrigated Area	Harvested
	m2	m2
Flood 1	48,463	48,463
Flood 2	44,861	44,861
Flood 3	25,834	25,834
Flood 4	26,348	26,348
Flood 5	69,244	69,244
Flood 6	30,800	30,800
Flood 7	58,786	58,786
Flood 8	15,844	15,844
Total Flood	320,180	
Spray 1	63,332	63,332
Spray 2	63,721	63,721
Spray 3	52,296	52,296
Spray 4	49,455	49,455
Spray 5	29,188	29,188
Spray 6	112,155	112,155
Spray 7	107,149	107,149
Mix Pasture *	110,387	183,978
Total Spray	587,683	
Total Irrigated		907,863
Total Harvested		981,454
* Proportion Spray Irrigated		0.6

Distribution of Irrigated Volume	
Percentage Spray Irrigated	95%
Percentage Flood Irrigated	5%

POND/STORAGE		Surface Area	Effective Max Depth	Effective Volume	Flows To
		m2	m	m3	
Treatment Ponds	Sludge	4187	2.41	10100	Irrigation
	Pond 2 Anaerobic	1840	2.12	3900	
	Pond 3 Anaerobic	1887	2.07	3900	
	Pond 4 Faculative/aerobic	4865	1.11	5400	
	Pond 5 Faculative/aerobic	3586	1.78	6400	
	Final Aerobic	9111	1.15	10500	
Recovery Ponds	First Flush Storage	2189			
	Tailwater	12339	1.22	15000	
Stock Water Ponds	Stock 1	4795			Stormwater
	Stock 2	2531			
	Stock 3	2404			

Total Site Area	266	ha
Abattoir	6	ha
Treatment Ponds	2.5476	ha
First Flush Pond	0.2189	ha
Tailwater Pond	1.2339	ha
Stock Water Dam	0.973	ha
Pond x ??	20996	ha
Bunded Areas Flowing To Treatment		ha
Abattoir Impervious		ha
Abattoir Pervious		ha
Flood Irrigation	32.0	ha
Spray Irrigation	58.8	ha
Grazed-not irrigated		ha
Not Grazed-Not Irrigated		ha
Balance	calc	

Wastewater Supply	260	ML/y
Supply Period	Day 49	start
	Day 344	finish
Supply Duration	43	weeks/y
Process Daily Supply	0.864	ML/d

Wastewater Composition		
Final Aerobic Pond		
Total Nitrogen	130	mg/L
Total Phosphorus	30	mg/L
Dissolved Salt	813	mg/L
Electrical Conductivity	1.95	dS/m
Biological Oxygen Demand	76	mg/L
Tail Water Pond		
Total Nitrogen	3.9	mg/L
Total Phosphorus	4.1	mg/L
Dissolved Salt	190	mg/L
Electrical Conductivity	0.22	dS/m
Biological Oxygen Demand	12	mg/L